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FEBRUARY, 1940

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Editor: G. A. COOK, M.Sc., B.M.E.

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The Control of Cumbungi (*Typha* spp.) in Irrigation Channels.

*By R. W. Prunster, B.Sc. (Agric.)**

1. Introduction.

Typha Muelleri and *T. angustifolia* var. *Brownii*, the two commonest species of the genus found in Australia, are tall cosmopolitan plants found growing in swamps and along watercourses. Plants of this genus are commonly known outside Australia as "cat-tail" or "reed-mace" and within the Commonwealth as "cumbungi," despite evidence in classical literature that the plant should be known as "bulrush." The common name, cumbungi, is claimed in some quarters to be an aboriginal name for the plant, while in others it is said to be an Egyptian native name introduced into Australia by soldiers returning from the Great War. The plant has therefore been mentioned in the literature since Moses was born 4,000 years ago, but investigations for its control have been commenced only in recent years.

In the Murrumbidgee Irrigation Areas of New South Wales and in the Goulburn and Murray River Irrigation systems in Victoria, cumbungi has created difficulties in the supply of irrigation and the removal of drainage water by growing so densely in the channel beds that water-flow was seriously impeded. Considerable expenditure was incurred by the New South Wales Water Conservation and Irrigation Commission and the Victorian State Rivers and Water Supply Commission in unsuccessful attempts to maintain the channel systems free of cumbungi.

The two Commissions jointly provided funds in 1936 for the Council of Scientific and Industrial Research to commence an investigation into methods of economic control of the weed. The investigation was carried out by the Division of Plant Industry and the writer was appointed for the work.

2. Nature of Infestation.

The nature of the cumbungi infestation can be best described by classifying the channels into their various types.

(i) *Main and Main Branch Canals.*—These canals convey irrigation water from the storage weir to the site for distribution. They are filled from September until May, and fluctuations in the depth of water are

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very slight. The depth of water in this type of channel will vary, with channel size from six feet to ten feet, and cumbungi grows along the edges of the channel out to a water depth of four feet six inches. In the early stages, the plant causes little obstruction to water flow (since it grows in the area of minimum velocity), but later it causes siltation and the formation of a shelf or berm at the channel's edge and thus slowly narrows the channel. (See Plate 1, Fig. 1.)

(ii) *Lateral Supply Channels.*—This type of channel is used for distributing water from the main canals to the irrigated farms. Except when rice is being grown, irrigation water is supplied to farmers on a 17-day rotation so that lateral channels are usually filled for three or four days during this period and are slowly drained during the remainder. This gives a close approximation to the swamp conditions forming the natural habitat of cumbungi.

Laterals are not usually of greater depth than three feet, so that cumbungi grows densely across the full width of infested laterals and seriously impedes water flow. Siltation also is very rapid, and there were occasions prior to 1936 when it was almost impossible to maintain efficient water distribution to settlers. (See Plate 1, Fig. 2.)

(iii) *Drains.*—Water flow in drains is irregularly intermittent and depends on the amount of surplus irrigation water to be drained away and also on the incidence of rain. Water depths fluctuate from a few inches to two feet, and water velocity is low, since the usual grade in New South Wales and Victoria is 1 in 10,000.

Cumbungi very rapidly infests this type of channel across its full width and causes more serious damage than in other channels. The removal of rice drainage waters in April becomes a serious problem, and following heavy rains the flooding of low-lying farms is inevitable, with its consequent waterlogging of soils and the killing of fruit trees and pastures.

(iv) *Natural Watercourses used as Drains.*—Shallow linked-up depressions are used in parts of the irrigation systems to convey drainage water. These watercourses have ill-defined banks and rapidly fill with cumbungi. Subsequent silting and the lateral spread of the plant makes the stream wider and shallower and gives rise to the formation of swamps along the length of the watercourse. Such waterways are much more difficult to maintain than the excavated supply and drainage channels above.

3. Manner of Spread of Cumbungi.

The plant may spread vegetatively or by means of wind-borne or water-borne seeds. *Typha Muelleri* develops 300,000 seeds per spike, and *T. angustifolia* var. *Brownii* as many as 700,000. Each seed is provided with a feathery attachment (pappus) making it easily carried for great distances by water or wind. Bore drains, miles from any known cumbungi, rapidly become infested by seed carried by winds and birds. Seedling plants are found in water from two inches to seven inches deep during the months of December and January. They are usually on a surface composed of fine organic silt and associated with a growth of fresh water algae. It is most usual to find seedlings in the bottoms of drains and along the water's edge in supply channels. However, there

is considerable evidence that the cumbungi seeds will not germinate along supply channel edges where grasses and rushes (*Paspalum dilitatum* and *Juncus* spp.) have developed. (See Plate 2, Fig. 2.)

Most trouble in channel systems is caused by spread from the underground parts. At the base of each upright plant the pseudo-rhizome develops a number of buds, each of which may elongate into a creeping rhizome and another upright plant with more buds. Once a channel has become infested with cumbungi, it is from these underground parts that regeneration occurs after treatment.

4. Previous Methods of Control.

It was usual in the Murrumbidgee Irrigation Areas to cut a swathe through supply and drainage channels once or twice each year to maintain water distribution and drainage services. In addition, drag line excavators were cleaning supply channels every five years and drainage channels every three years. Despite this treatment the number of channels infested was increasing. An amount of £15,000 per annum was spent directly as a result of cumbungi infestation but yet the problem remained.

The continual excavation of channels led to their enlargement and a loss of grade, so it was foreseen that the whole of the 2,000 miles of constructed channels would need to be renewed within 30 years. Thus the capital expended on channel construction only 25 years before did not provide a permanent asset as was originally expected.

5. Experimental.

Details of the experiments conducted will not be given in this article, but a brief outline of the types of experiments and the results obtained will be included.

(i) *Chemical Sprays.*—It was found that none of the common weed-killers gave a satisfactory kill with a single application to the foliage of cumbungi. Sulphuric acid, sodium arsenite, sodium chlorate, and an "acid-arsenical" were ineffective at all economic concentrations. However, in a water depth of nine inches, a 15 per cent. solution of sodium chlorate gave a good kill when applied three times at two-monthly intervals at the rate of 500 gallons per acre, the first spray being applied at flowering. A reasonable kill was given by an oil-water emulsion containing 5 per cent. arsenic (as sodium arsenite) and 20 per cent. crude oil.

Though fairly effective, the treatments were uneconomic, as, for a channel six feet wide, the cost of material alone was in the vicinity of £25 per mile of channel treated.

(ii) *Soil Sterilisation.*—During the winter months, a section of disused channel was drained and all aerial parts of cumbungi were removed. From 2 to 8 cwt. per acre of the following were applied to the soil:—sodium chlorate; 8 parts borax, 1 part sodium chlorate; arsenic (with or without an equivalent amount of ferrous sulphate or aluminium sulphate); and sulphates of iron and aluminium. In spring the channel was slowly filled with water, but no noticeable effects were obtained except on the chlorate plots where the plants were slightly reduced for a few months.

(iii) *Cutting.*—Cumbungi was cut at ground level and below water at intervals varying from one to eight weeks, the first cutting being carried out at flowering time. It was found that only plants at, or above, the water's edge survived frequent cutting, and that the frequency of cutting necessary depended on the depth of water in the channel. Thus in a channel of more than 15 inches depth it was found that 96 per cent. of the original population was killed with six cuttings at six-weekly intervals, and in a drain with a fluctuating water depth not exceeding 15 inches six cuttings at four-weekly intervals killed 88 per cent. of the plants. It is an interesting point that the population decreases almost by geometric progression, so that the work involved in each succeeding cutting is greatly decreased. Cutting was carried out with short bladed scythes or by means of a special horse drawn cutter constructed by the Commission.

A simple explanation of the reason for the death of the plant following frequent cutting may not be out of place. Plants growing at the water's edge have some, at least, of their roots in aerated soil. These roots are well branched and are adapted for obtaining their air supply from the surrounding soil. But plants with their roots under water have a different type of root system. Embedded in the surface silt of the channel bottom are finely divided roots with a large surface area and best known as water roots but more aptly described as feeding roots. Below these are a second type, thicker, and more sparsely branched, the branches being short and bearing numerous root hairs. The third type, and the deepest, are thick and almost unbranched but bearing numerous root hairs. The presence of root hairs has been pointed out by Cannon of the Carnegie Institute to be rather a symptom of deficient aeration than of increased water supply. Air supplies for these roots diffuse down through spongy air-conducting (aerenchyma) tissues of the leaves to similar tissues of all underground parts.

The rhizomes of the plant contain up to 56 per cent. of their dry weight as starch dextrins and reducing sugars. When air supplies are obtainable from the leaves above, the energy for growth may be obtained from the starch and sugars, and the resulting products of the starch breakdown are carbon dioxide and water. If, however, air is not obtainable from above (as when the plant has been cut), the starch will give up only a small portion of its energy. This anaerobic respiration is really a fermentation process, and alcohol and several organic acids are produced in the underground parts of the plant as a result. If the plant is kept cut, the accumulation of these products kills all the underground parts by their poisonous effect, but if the leaves appear above water for any considerable periods (as with one or two cuttings in the year) the respiration processes may be completed in the presence of air sent down from the leaves, and the poisonous products may be removed.

It is interesting to note here that, because of the bulk of the underground parts and the large amount of starch they contained, Australian and New Zealand natives made use of cumbungi for food. Remnants of their cake-cooking clay ovens are still to be found between Cohuna and Swan Hill. It is said that the plant has medicinal value as a diuretic.

6. The Patrol System.

The large capital expenditure incurred in constructing an irrigation channel system made it necessary to devise some means of making control practices permanent. Even after re-excavating the channels, the small amount of underground parts of the weed left at the channel's edge soon re-infested the channel.

Railway and telephone systems have men employed as length-runners or linesmen whose duty it is to patrol a section of line, repair minor damage, and report where major works are necessary. Such a patrol scheme keeps the railways and telephone systems highly efficient and prevents major breakdowns. It was considered that a similar patrol was justified along irrigation channels.

It will be readily seen that cutting treatments were of little use in badly silted channels, for after removing the cumbungi it would still be necessary to use a drag-line excavator to remove silt. Thus, in badly silted drains or supply channels, the drag-line excavator was used to remove cumbungi and silt, and in silt-free supply and drainage channels cutting was carried out at six-weekly intervals until all but the water's edge plants were killed. By maintaining the water level as high as possible in supply channels, the number of cuttings necessary was kept at a minimum.

At this point the channels are placed under patrol. In 1937 it was considered that 20 miles of supply and 20 miles of drainage channel would provide as much as one man could perform on a fortnightly patrol. Since then this length has increased and each patrolman in the Murrumbidgee Irrigation Areas looks after 67 miles of drainage and supply channel. A horse and sulky is used for transport.

The first duty of the patrolman is to remove the few plants remaining at the water's edge. This is usually done by means of a hoe or mattock, and during the first season it is necessary to inspect the channels fortnightly. During December and January, it is necessary to prevent seedling infestation in drains. In his own section a patrolman soon recognizes the low spots in drains where pools form and seedling infestation is liable to occur. The seedlings are removed with rakes before their roots obtain a firm hold in the silt.

There is some evidence that the amount of seed germinating decreases each season after the initiation of the patrol. The enormous crop of seedlings in drains during the first season probably develops from seed accumulated over a number of years. It is found also that after a season's patrol *Paspalum* and *Juncus* spp. colonize the supply channels at the water's edge and prevent the germination of *Typha*. It is therefore possible after the first season to increase the amount of channel patrolled by each man. In a little more than two years, this has increased from 40 miles to 67 miles of channel per man.

In addition to preventing re-infestation by cumbungi, each man removes small obstructions from the channels such as the silt bars occuring at farmers' outfalls into the drains. It is now estimated that, as a result of the removal of cumbungi and the institution of the patrol system, the cleaning of channels by means of the excavator will be necessary in drainage channels only once in 15 years, and in supply

channels only once in 20 years instead of at three and five yearly intervals as formerly. Further, since only silt will be removed, there will be no need to widen the channels when cleaning and there need be very little loss of grade.

The channel attendant superintending the patrol men makes regular inspections of cleaned channels and enters into a field note book the work done in maintaining the channel and the efficiency of the channel. These notes are entered on indexed folio cards for quick reference, and at any moment the history of that channel may be obtained. The field notes are accepted in law as evidence of the work done in maintaining the efficiency of the channel.

By continuing the cycle of cutting and bringing channels under patrol during the October-March period each year since 1937, it has been possible to clear completely of cumbungi the worst infested 900 miles of the 2,000 miles of supply and drainage channel in the Murrumbidgee Irrigation Areas. This length of channel is now being patrolled by 13 men at a cost of little more than £3,000 per annum. But the difference between this figure and the £15,000 per annum does not represent the total saving, for to this must be added the fact that the channels are now permanent assets and the water distribution and drainage system is more efficient.

7. Acknowledgments.

This investigation would, no doubt, still be in the experiment plot stage but for the kindly and ready assistance of Mr. F. K. Watson, Divisional Engineer of the New South Wales Water Conservation and Irrigation Commission. It was due to him that the results of the experiments were put into extensive field tests and that the patrol system was instituted and rigorously followed up.

My thanks are also due to Dr. G. A. Currie, now Professor of Agriculture in the University of Western Australia, for his kindly guidance in this work, and to Mr. E. S. West, Officer-in-Charge of the Irrigation Research Station, Griffith, for providing laboratory space and kindly criticism. The officers of the Victorian State Rivers and Water Supply Commission also provided useful information and transport through the Victorian irrigation areas.

Polledness in Cattle.

*By R. B. Kelley, D.V. Sc.**

During a discussion on the question of the inclusion of Polled Herefords in the Pedigree Stock Scheme at the Tenth Meeting of the Australian Agricultural Council, attention was directed to the difficulties which many breeders of Polled Hereford cattle in the United States were experiencing in disposing of the product of their studs, and it was also stated that some owners who had used Polled Hereford cows were now using horned bulls with them.

Subsequently, Dr. R. B. Kelley was asked to prepare a popular article outlining the essential facts regarding the condition known as polledness in cattle and its specific mode of inheritance. In the following paper Dr. Kelley describes the underlying principles of inheritance of polledness, and a method of procedure, which, with a full knowledge of the genetical processes involved, will enable breeders to anticipate and control the results of any given mating.—Ed.

1. Introduction.

Recently, emphasis has been placed upon the loss to producers occasioned by bruising in beef carcases. Among the disclosed causes, it is generally accepted that horn bruising is important, particularly if it occurs when cattle are mustered, drafted, and yarded for trucking and slaughter. To prevent bruising of this kind, "tipping" and "dehorning" are widely advocated.

"Tipping" involves simple surgical removal of the tip of the horn, whereas "dehorning" can be effected by the use of caustics on the horn buds soon after the animal's birth, by the use of relatively simple surgical appliances at marking time, or by special cutters after the horn is well developed.

It is possible also to "dehorn" by breeding, and for this purpose polled breeds of cattle are becoming increasingly popular. A knowledge of the genetical processes involved, however, is a fundamental requirement for success with this method, which places within the hands of breeders a rational procedure by which results can be anticipated and controlled. This knowledge also explains what appear to be anomalous results sometimes observed.

2. Mendel's Theory of Heredity.

Commonly, in sale catalogues and elsewhere, references are made to the "blood lines" of livestock. It is often inferred, incorrectly, that the hereditary characteristics of offspring are carried in the blood fluid of the parents, more particularly in that of the dam. For example, the Bruce Lowe theory for thoroughbred horses places a family number against a present day horse. This corresponds to that given to a mare many generations back because the "blood" is regarded as having flowed in a direct line from the original mare to the present day animal.

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This conception of livestock inheritance was in agreement with the early belief that each generation was a blend of its progenitors. Perhaps the most outstanding result of the discoveries of Mendel and of the work of his followers was proof that this belief is erroneous. They have shown that inheritance is fractional.

The two theories can be illustrated admirably by representing the parents and the offspring as transparent glass vessels.

To illustrate the earlier idea, fill one glass vessel with red wine and the other with water. These two represent the parents. Into the third glass, representing the offspring, pour an equal quantity of fluid from each of the "parental" vessels. The result is a diluted red in the "offspring" glass.

To illustrate the newer idea, fill each "parental" glass with an equal number of glass beads of highly assorted colours, each colour representing a parental characteristic. Now agitate both glasses as vigorously as a dice box is "rattled" and "throw" an equal number of beads from each into the third vessel. The result represents the offspring.

It is obvious that, in the first instance, equal quantities of the fluids will always give the same degree of colour in the third or "offspring" glass. On the other hand, the admixture of beads which the corresponding glass contains in the second instance, will be controlled wholly by chance, operating within the range of possibilities contained in the "parental" glasses.

It has been proved over and over again that the second procedure illustrates what actually takes place when two animals are mated.

If, now, attention is focussed upon beads of a particular colour in the "parental" glasses, the illustrations can be carried still further. Before this can be understood readily, however, it is necessary to state certain established scientific facts.

The bodies of all animals are made up of millions of minute cells; those forming such parts as the limbs, skin, muscle, etc., are called somatic or body cells, while those responsible for reproduction are called germinal cells.

Cells of both kinds have a central portion called the nucleus which consists largely of material which can be stained or dyed by basic dyes and is therefore known as chromatin material. When cells multiply by dividing into two, this chromatin material breaks up into small parts called chromosomes. The number of chromosomes per cell is always the same for a particular species of animal but each chromosome within the same cell differs. There are, however, two types of division for the chromatin material. That in somatic cells is so arranged that each daughter cell receives the full number of chromosomes, i.e., the chromatin material increases in amount and half goes to each new cell. In germinal cells on the other hand, the process is different. It is represented diagrammatically in Fig. 1 which shows also fertilisation by fusion of the male and female cells. For the purpose of illustration, the somatic cells are assumed to possess only four chromosomes (shown as short vertical lines).

The diagram shows how, in the male and female germinal cells, the number of chromosomes becomes reduced by half. But each germinal cell, when it meets the other at fertilisation, contributes its half, and the resultant cell (the zygote) has the full number typical of the particular species (in this case four).

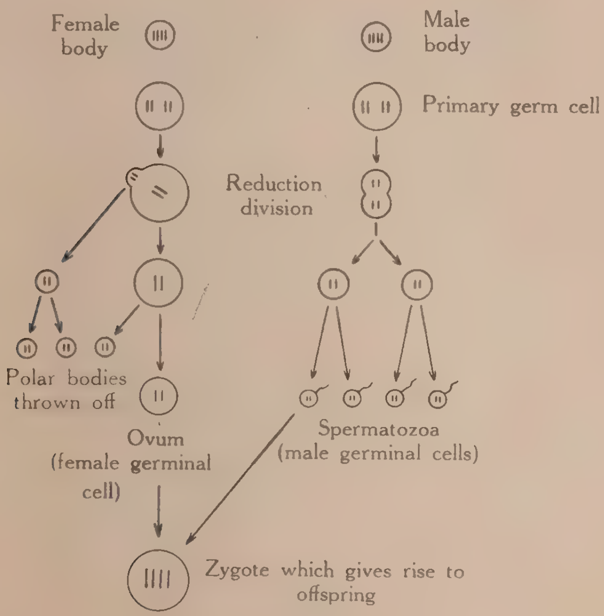

Fig. 1.

In the diagram, on the female side, three nuclear parts (polar bodies) are shown as discarded, and on the male side three of the four available spermatozoa fail to fuse with the ovum. Thus only two out of eight chromosome samples "carry on".

Nevertheless, these chromosomes are the vehicles by which inheritance is transmitted, and characterization, as for the offspring in the diagram, is predetermined by substances or minute particles carried upon the chromosomes. The substances or minute particles are called "genes", and the word "genotype" is used for the make up of the individual as far as "genes" are concerned.

The chromosomes in the nucleus of the fertilised cell are paired, and in every pair one chromosome is originally derived from the mother and one from the father. When a certain gene is inherited from both parents, the chromosomes are so arranged in the nucleus that those two genes are placed side by side, and this is possible for all the genes because they are arranged in a definite order on the chromosomes.

Now to return to the glasses and beads.

The beads in each "parental" glass collectively can be regarded as representing the genotype of the animal. Suppose that, among all other kinds of beads, the glass representing the male has two white beads and that representing the female also has two white beads, i.e., in each case these beads are paired.

It is impossible to cause the beads to undergo reduction division like the living cells in the diagram above, but it is possible to separate them by agitation and to "throw" in such a manner that only one white bead comes out of each "parental" glass into the "offspring" glass. When this is done the process, as an illustration, has been carried as far as fertilisation (see Fig. 1) and the two white beads, representing genes, are side by side in the fertilised egg.

The white beads of course could be round or square. Let us imagine that those in the male glass were square and that those in the female glass were round. Under these conditions the offspring glass would always contain one round and one square bead, no matter how many times the "throw" was made. When, however, as in a later generation, a male "offspring" glass becomes "parental", with a round and a square white bead, and is mated with a female "offspring" glass (also now "parental") containing a round and a square white bead, and again chance operates in the "rattle" and the "throw", there are several possibilities.

These, for all cases, are shown diagrammatically as follows:—

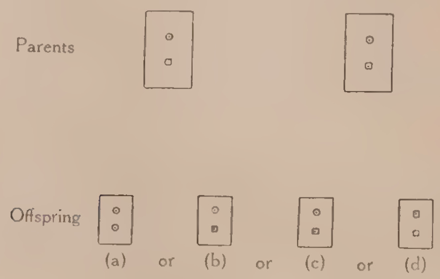

FIG. 2.

Of course there would be many other kinds and numbers of coloured beads in the "offspring" glass just as there were in the "parental" glasses but, for our present purposes, all the other kinds are disregarded. We are considering only the method by which characters are inherited when dependent upon genes represented by white beads, as distinct from other characters represented by beads of any and all other colours.

This is the basis of Mendel's particulate or fractional inheritance.

If now we revert to genetic terminology, we will call the single white beads "gametes", as they pass from the parental glass to the "offspring" glass, and when they are in the offspring glass we will

call them a "zygote" and assume that they have fused as during fertilisation. Further, instead of describing each pair as "square white beads" and "round white beads", we will give them letters of the alphabet. The two square ones we will call capital "PP" and the two round ones small "pp". The capital letter as compared with the small letter conventionally indicates "dominance", which means that, as the result of experience, it is known when animals with the genotype represented by PP are mated with animals represented by pp then the offspring will all show whatever character PP represents.

We are now in a position to apply the foregoing to the inheritance of polledness in cattle.

Polledness has been shown by many experiments to be almost completely dominant over the horned type in this species. Thus, cattle with the genotype PP or Pp will appear polled, those with the genotype pp will appear horned, and these symbols will indicate their breeding possibilities, regardless of those for all other characters, just as truly as the while beads were independent of all other coloured beads in the glasses.

3. Discussion of Different Matings.

It is thus possible, depending upon the kind of bull used, to make nine kinds of matings among which three repeat themselves.

	Bull.		Cow.		Mating No.
Series I.—					
	PP	x	PP	..	1
		x	Pp	..	2
		x	pp	..	3
Series II.—					
	Pp	x	PP	..	4
		x	Pp	..	5
		x	pp	..	6
Series III.—					
	pp	x	PP	..	7
		x	Pp	..	8
		x	pp	..	9

These will be examined in detail as set out above.

Series I.—The bull in this series is polled and has two capital P's in his genotype. In genetic terminology he is referred to as a homozygous dominant. The word dominant has already been explained; *homos* means the same, and *zygos* an egg. The word thus connotes that animals of this kind always give the same kind of egg or gamete.

Mating No. 1—(PP x PP).—The bull meets the same kind of a cow, both being homozygous (PP). Each thus gives rise only to P gametes. The progeny (from the zygote) are invariably PP, are always polled, and bear or beget only polled stock.

Mating No. 2.—(PP x Pp).—The cow, although polled, can give two kinds of eggs or gametes, namely P and p. These always meet P gametes from this bull with the following possibilities:—

Parents PP × Pp

Gametes P ⟶ P (arrows indicate all possible combinations, four in number.)

P ⟶ p

Zygotes PP Pp
PP Pp

2PP + 2Pp

From a mating of this kind, in which the bull and the cow are both polled to *look at* (i.e., their phenotype is polled), all the progeny are polled.

Attention is drawn however to the fact that the cow was heterozygous (i.e., she gave rise to different kinds of egg cells), and that among the progeny from a large number of such matings, one half would be homozygous—e.g., 2 out of the above 4 possible combinations—and these would produce P eggs only, while the other half would produce both P eggs and p eggs and under particular conditions give rise to some horned calves. The importance of this will be emphasised later.

Mating No. 3.—(PP x pp).—The female is a horned cow and gives only one kind of egg, namely p. This female is therefore called homozygous but, because we are considering a character (polledness) which is, for all practical purposes, completely dominant, the cow can only show the recessive condition when she is of the double pp or homozygous type.

Parents PP × pp

Gametes P ⟶ p (arrows indicate all possible combinations.)

P ⟶ p

Zygotes Pp

In this case all the progeny will be polled. All, however, would be heterozygous and capable of producing horned progeny because, when mated, they would give two kinds of eggs (P and p).

Series II.—In this series of matings the sire is represented by Pp i.e., he, although polled, can give two kinds of eggs or gametes. It will be shown in this series, that his progeny will appear horned or polled, depending upon the kind of cow he mates with.

Mating No. 4.—(Pp x PP).—The position is similar to that in No. 2 except that here the homozygous animal is the dam. In both cases, however, because each parent contributes equally to the inheritance of the offspring, the result is the same. The progeny are all polled, half being heterozygous (capable of producing different gametes, and so possibly horned calves).

Mating No. 5.—(Pp x Pp).—This is the mating which gives rise to what have been regarded as anomalies. It is fundamental to the whole question and, indeed, would have provided material for the whole discussion if this would have been intelligible without the foregoing.

Both sire and dam, although polled animals, are heterozygous (Pp). Each is thus capable of producing two kinds of gametes and these, when all possible combinations are considered, upon occasion unite to give horned progeny.

Parents Pp × Pp

Gametes P ⟶ P (arrows represent all possible combinations.)

p ⟶ p

Zygotes PP Pp pp
Pp

PP 2Pp pp

Thus, when sufficient progeny result from such matings, 75 per cent. will be polled (for they will contain P), and 25 per cent. will be horned. Further, only one out of every three of the polled animals (the one with PP genotype) will leave polled offspring if mated with all classes of cattle (see Series I.).

Mating No. 6.—(Pp x pp).—Here a polled bull is mated with a horned cow. Once again it is emphasised, however, that this bull, although polled, is heterozygous (Pp). He thus gives rise to gametes which cause confusion if the position is not understood. The expected percentages from such matings are determined as follows:—

Parents Pp × pp

Gametes P ⟶ p (arrows indicate all possible combinations.)

p ⟶ p

Zygotes Pp pp
Pp pp

2Pp + 2pp

This mating, therefore, when sufficient numbers of progeny are available, will leave 50 per cent. of horned calves (pp) and 50 per cent. of polled calves (Pp). These polled calves are heterozygous, however, and although polled will sometimes produce horned and sometimes polled cattle, depending upon the genotype of their mates.

Series III.—This series, except for No. 9, repeats matings already discussed. However, in the instances 7 and 8 the polled and horned animals are of different sexes. No. 7 is the equivalent of No. 3, and No. 8 of No. 6.

Mating No. 9.—(pp x pp).—This is the ordinary mating of horned bulls and horned cows which, except in very rare instances, gives only horned calves. The exception is known as a "sport" or "mutation"

Parents pp × pp

Gametes p ⟶ p

p ⟶ p

Zygotes pp—all horned.

4. Application to Cattle Breeding.

We are now in a position to discuss the possibilities when existing breeds of cattle are mated.

Gallaway, Aberdeen Angus, and Red Poll cattle have been established polled breeds for many years. Thus, although in their earliest days some of the animals may have been horned, and history states this to have been the case, pure cattle of these breeds with established pedigrees should be homozygous and have a genotype represented by PP.

Reference to Series I. above will show that cattle of this kind will leave polled offsprings regardless of the genotype of their mates (PP, Pp, or pp). This, however, is not invariably true for cattle graded up to these breeds, because among them some will be heterozygotes (Pp).

If, therefore, horned cows of any breed (pp) are mated with pure bulls (PP) of these three breeds, we have mating No. 3 of Series I.

If, however, bulls of this first cross (Pp) are mated with horned cows (pp) we get mating No. 6 of Series II. and 50 per cent. of horned calves.

If, on the other hand, the first cross bulls are mated with pure cows of these breeds (PP) or, as is more usual, the first cross cows (Pp) are again mated to pure bulls (PP), all the progeny will be polled, but 50 per cent. of them (being Pp), under certain conditions, will leave horned progeny.

The grading up process is shown diagrammatically in Fig. 3 for several generations in a supposed herd which began with 100 horned cows (pp). Among these, for one year, and later with their progeny, pure polled bulls (PP) were continually introduced.

For simplicity, every calf is assumed to bear or beget progeny and no parental generation is reconsidered. The figures represent actual numbers possible, based upon the percentages already given for particular matings. The scheme is wholly diagrammatic and is presented to illustrate the decreasing chance of heterozygous animals (Pp) occurring in late generations after a considerable number of such matings.

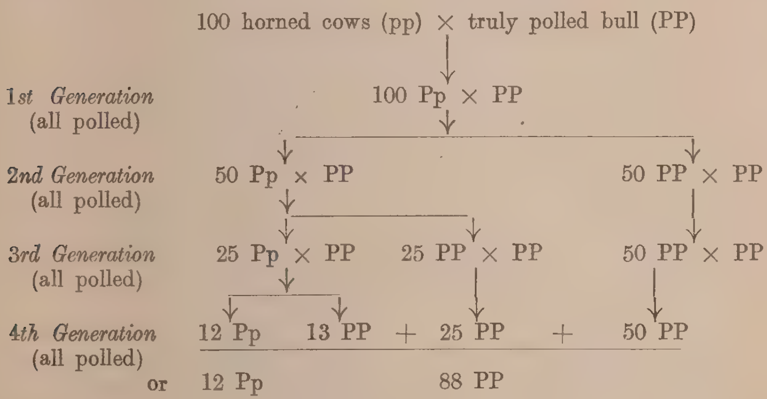

Fig. 3.

In a graded up herd such as that shown above, if an outstanding bull were discovered among, say, those born in the 4th generation, it is obvious that he would have approximately only a 12 per cent. chance of being heterozygous (Pp) and an 88 per cent. chance of being homozygous (PP).

The horned condition has been stated to be recessive to that of polledness. Further, it has been shown that, whereas PP bulls cannot leave horned progeny, Pp bulls can, and do so when mated with horned cows.

These facts provide a critical test by which the outstanding bull can be allocated to either the 12 per cent. or the 88 per cent. group.

He should be progeny-tested by mating with a sufficient number of horned cows (pp) (probably 20 would be sufficient) when, if he is PP, he will leave no horned calves. In such a test mating one solitary horned calf is sufficient to classify the bull as Pp.

Polled Shorthorns and polled Herefords, with regard to polledness, are largely "graded-up" cattle. The position in the United States of America in regard to these cattle, is concisely stated in the following extract taken from a letter to us, dated 11th September, 1939,

from Mr. E. N. Wentworth, Director of Armour's Livestock Bureau, Armour and Company, Union Stock Yards, Chicago, United States of America.

> "The polled character in both Shorthorns and Herefords was discovered in mutants or 'sports' in the pedigreed animals. The earlier breeders did their best by mating polled animals on both sides of the pedigree to fix the polled character in each breed, and they met with a considerable degree of success. The polled Shorthorn breed somewhat antedates my contacts with the cattle industry, but the polled Hereford breed has been developed in the interval since I have been in intimate touch with cattle. In both cases the polled character was fixed rather definitely, so that the majority of the animals bred true for the characteristic.
>
> "However, during the period in which these cattle have been bred, there has been a marked change in conformation, quality and general character of the beef animals in all breeds that win at the shows. The horned Herefords and Shorthorns have adapted themselves to this change rather well, because they are bred in large numbers, and have a large hereditary field on which to draw, in order to develop animals more nearly suited to our present-day demand. On the other hand, the two polled breeds were much more limited in hereditary material. They could not preserve the purity of the polled character and at the same time adapt themselves as quickly to the modern standards applied in the market and the show ring.
>
> "Consequently, the breeders both of polled Herefords and polled Shorthorns have crossed back into the horned breeds in order to introduce something of the type which has now become more popular. They have done this intentionally and have usually informed buyers and fanciers of the breed as to their purpose in so doing. On many occasions they have offered practical advice as to methods of mating.
>
> "If I were to sum up the situation, I should say that there has been a temporary sacrifice of homozygosis, or purity, in the polled character in order to improve the conformation and carcase quality. Now that breeders know so much about the inheritance of the polled character, I do not believe that the loss of homozygosis is at all important in contrast with the gain in carcase character.
>
> "I, myself, purchased two bulls for export to a client of the company in Brazil last spring and purchased one bull of each type; namely, one which I felt was quite certain to be homozygous for the polled character, and another which I knew was heterozygous, but which had great advantage in conformation and substance. I explained to the purchaser that he should use the second bull in the purebred herd which he maintained to breed sires for his range herd. I pointed out that I felt that the improved conformation more than offset the heterozygous condition of the polled character, and fitted the bull particularly for the purpose desired."

In the United States of America, the home of these two breeds, all polled Shorthorns must conform to the regular rules of eligibility for entry in the American Shorthorn Herd Book.

A Double Standard Polled Hereford is any pure-bred Hereford that is naturally polled and is registered in the American Polled Hereford Record and in the American Hereford Record.

A Double Standard Polled Hereford may have:—

(*a*) a polled sire and a polled dam;
(*b*) a polled sire and a horned dam;
(*c*) a horned sire and a polled dam; or
(*d*) a horned sire and a horned dam (as in the case of mutations such as those from which the breed was originated).

It is evident, therefore, that only some of the registered polled Herefords will be homozygous for polledness. This emphasises the necessity for breeders to have a knowledge of the genetic principles involved and the importance of the progeny test already described. It does not reduce, however, the usefulness of these breeds for Australian conditions.

Dr. John Hammond's endorsement of this statement is clearly shown in his letter to us dated 1st September, 1939.

> "In reply to your letter about polled types of Herefords and Shorthorns—The polled character can be transferred to a breed without affecting its development or constitution in any way. I have seen, in the Argentine, a herd of polled Shorthorns equal in conformation to any of the horned types (Snr. Martenez de Hoz, Chapadinalal, Buenos Ayres Province). As a whole, however, the conformation of the polled types of Herefords and Shorthorns is not quite so good as that of the horned types because there are not so many breeders—this, I believe, is the only reason.
>
> "It is quite an easy matter to breed on the hornless character to any carcase type—as the polled character is Mendelian in inheritance and the carcase type is multiple factor. Take for example the Hereford—a polled Hereford bull can be bred to some good conformation Hereford cows, a polled bull from this cross can be mated to such cows again, and so on until the conformation is as good as that of the original cows. When this is done it is merely a matter (as you know) of testing the bulls and cows for recessive hornlessness and then breeding the pure polled together.
>
> "I am convinced that it would well repay you in Australia to build up herds of both polled Shorthorns and polled Herefords. Costs of dehorning are large, the process means rounding up, while the losses to the carcase quality by animals horning one another are large. All you need to do it is *a few bulls* and a planned system of breeding on the stations which carry them."

In the second paragraph of Dr. Hammond's letter, it is stated that carcase type has a "multiple factor" inheritance, an expression which requires explanation.

This method of inheritance, although quite common, and similar to that already described for characters dependent upon small numbers of factors or genes, is not so clear cut for descriptive purposes. Further, the homozygous types cannot be expected among very small numbers of progeny.

The reason for this can be illustrated by a return to the beads and glasses with which we demonstrated the possibilities with regard to white-round and white-square beads when these were paired.

If several hundred red beads of various shades were included in each "parental" glass and they also had many shapes, it would be

extremely rare for an exactly paired set to be "thrown" into the "offspring" glass.

This also is so for characters dependent upon many genes (multiple factors). The sire adds some to those in the gamete of the dam, and the zygote, and thus the offspring, carries a degree of characterisation dependent upon the type and number of these genes.

Characters dependent upon multiple factors arrange themselves in a series which can be seen in any unclassed flock or herd. On the two extremes are the very bad and the very good, while the majority of the flock is intermediate between these. Such an arrangement is shown graphically in Figure 4.

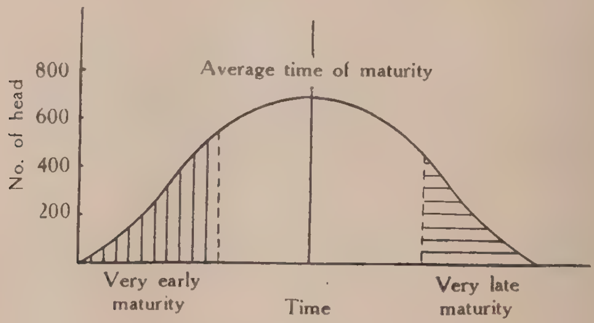

FIG. 4.

Under ordinary conditions of mass selection for early maturity, animals represented by the horizontal hatching would be culled, future herd sires would be retained from the vertically hatched group, and the bulk of the flock or herd would be found between the two dotted lines.

This type of selection for sires, based upon appearance only, is unsound unless immediately followed by progeny testing.

When an animal is not only among the highest grades himself (vertical hatching) but also uniformly leaves progeny of this class, his sire and dam both must have subscribed a particularly good assortment of genes to his genotype and such a happy accident should be followed by appropriate line breeding.

These aspects of animal breeding, however, are beyond the scope of this paper, which has been confined to the principles underlying the inheritance of characters controlled by a small number of genes, and particularly to the inheritance of polledness in cattle which, as is customary for practical purposes, has been considered dependent upon one pair of genes.

Studies on Mastitis in Dairy Cows.

Summary of Results of Bacteriological and Clinical Investigations during the first two Lactation Periods in an Experimental Herd.

Mastitis in cows is a world-wide and troublesome disease. Much investigational work on the condition has been carried out in Europe and America, but the results have not led to any easy and effective method of control.

In Australia, the problem has been serious for many years—so much so that, some time back, dairying interests decided to provide much of the finance necessary to enable the Council's Division of Animal Health and Nutrition to make a commencement on a study of the disease; this decision was made despite the realisation that the investigations would in all probability be difficult and long-dated.

The work in question was commenced by the Council in 1935. It has been financed by the Australian Dairy Cattle Research Association (now the Australian Cattle Research Association) by a fund collected from the Commonwealth Government, the Commonwealth Bank, the Victorian Government, and the dairy industry through its national organisation. The investigation was placed under the direction of Dr. L. B. Bull (Chief of the Division of Animal Health and Nutrition) with the assistance of an Investigation Committee consisting of Dr. H. E. Albiston (Director, Veterinary Research Institute of the University of Melbourne), Mr. R. J. de C. Talbot (Superintendent of Livestock, Victorian Department of Agriculture), and Dr. A. W. Turner (Division of Animal Health and Nutrition). The bacteriological work has been carried out by Mr. E. Munch-Petersen and Mr. D. Murnane, with the assistance of Miss S. E. R. Clark and Miss J. D. MacLean. The experimental herd has been under the control of Mr. D. Murnane, who has also been responsible for the clinical aspects of the investigation.

In America and Europe, investigators of the disease have been hampered in that their work has been largely centered around the end result, i.e., the diseased animal; they have not done much in the examination of the facts leading up to the development of the disease in a clean herd. The Australian work is somewhat unique in this respect.

The first scientific report on the results of the work has now been prepared. The report deals with (1) the establishment and management of the experimental herd, (2) bacteriological, cytological, and clinical investigations on the experimental herd, (3) the laboratory methods, cultural, serological, and cytological, used in the investigation, and (4) discusses the results obtained during the first two lactation periods.

The report will be published in full at the first opportunity. In the meanwhile, a brief summary of it is given below.—Ed.

Summary.

1. A milch herd. was established by the selection of non-pregnant heifers with the addition of a few in the early stages of the first pregnancy. All animals were proved to be free from tuberculosis and contagious abortion before being admitted to the herd. The methods adopted in the establishment and general management of the herd are described in the paper.

2. Fifty heifers were secured, and thirty of those first coming into production were chosen as the experimental herd on which intensive bacteriological and clinical examinations have been made.

3. Bacteriological examinations of the milk from each quarter of the udder have been made at regular fortnightly periods, supplemented by special examinations in some instances. The results obtained during the first two lactation periods have been analysed and are summarized in the several sections.

4. During the first week in the lactation of each cow, bacteriological examinations were made daily.

(*a*) In the first lactation, 73 per cent. of the 119 functioning quarters were sterile during the first week. Appreciably high bacterial counts in the milk from the other 32 quarters were present for one or more days and were due to "non-haemolytic" micrococci which tended to disappear before the end of the week: in 3 of these quarters the infection persisted for the first seven days. *Str. agalactiae* was recovered from 16 quarters during the first week but persisted in no case.

(*b*) In the second lactation, 48 per cent. of the 118 functioning quarters were sterile during the first week. In the other 61 quarters, infection persisted for various periods, being present for the first seven days in 46 quarters (39 per cent.). *Str. agalactiae* was recovered from 5 quarters during the first week.

(*c*) There was no tendency for the bacterial status of the quarter in the first week to be reflected in the bacterial status during the rest of the first lactation period. In the second lactation period, however, 72 per cent. of the quarters sterile in the first week remained sterile, and [illegible] per cent. of those with appreciable counts in the first week showed relatively high counts during the rest of the lactation period.

5. Bacteriological examinations were made at fortnightly intervals after the first week.

(*a*) During the first lactation period, 50 per cent. of the 119 quarters remained sterile. The remaining [illegible] quarters gave appreciably high counts for various periods, 8 of them throughout the whole period. For the most part the persistent high counts were due to "non-haemolytic" micrococci, but haemolytic staphylococci contributed to the high count in 17 quarters (14 per cent.) and *Str. agalactiae* in 9 quarters.

(*b*) During the second lactation period, 34 per cent. of the 118 quarters remained sterile. The remaining 78 gave appreciably high counts for various periods, [illegible] (42 per cent.) of them throughout the whole period. "Non-haemolytic" micrococci were responsible for the majority of the persistent high counts, but haemolytic staphylococci contributed to the high count in 22 quarters and *Str. agalactiae* in 2 quarters.

(*c*) In each lactation period, infections by both micrococci and the staphylococci tended to become permanent, but those due to *Str. agalactiae* were transient

6. (*a*) During the first lactation period *Str. agalactiae* was recovered from the milk of 13 cows (43 per cent.) and 30 quarters (25 per cent.). It was recovered on a single occasion from 18 quarters, on two isolated occasions from 3 quarters, and in 9 quarters the infection persisted for from 2 to 12 weeks. It produced clinical mastitis in two quarters.

(*b*) In the second lactation period, *Str. agalactiae* was recovered from the milk of 21 cows (70 per cent.) and 43 quarters (36 per cent.).

It was recovered on a single occasion from 28 quarters, on two isolated occasions from 11 quarters, on three or four isolated occasions from 4 quarters, and in 2 quarters the infection persisted for 3 and 14 weeks, respectively. It produced clinical mastitis in one quarter.

(*c*) These results are based on regular fortnightly examinations. When the examinations were made more frequently, the streptococcus was found more often and in a larger number of cows.

7. The strains of *Str. agalactiae* (serological Group B of Lancefield) recovered from the herd have been classified by agglutination methods into two types, Type 1 and Type 7A. Type 1, which has predominated, has been devided into six subtypes. Type 7A has occurred slightly less frequently. Several strains have failed to fall into either of these types. On the basis of the differentiation of the streptococci into types and subtypes, the data have been examined to determine if the chance of a cow's harbouring more than one type increases with an increase in the number of quarters involved or with an increase in the number of infections experienced. A statistically significant association has been found in each case.

8. Streptococci not belonging to the serological Group B have been isolated from time to time from the quarter samples of milk.

(*a*) During the first lactation period, these streptococci were recovered from 22 cows (73 per cent.) and 37 quarters (31 per cent.). They were recovered on a single occasion from 31 quarters, on two isolated occasions from 5 quarters, on three occasions from 1 quarter, and the infection persisted for four weeks in 1 quarter without producing clinical symptoms.

(*b*) In the second lactation period, they were recovered from 27 cows (90 per cent.) and 68 quarters (59 per cent.). They were recovered from 42 quarters on a single occasion, from 13 quarters on two isolated occasions, from 8 on three occasions, and from 5 quarters on four, five, or seven occasions.

(*c*) Thus, these streptococci were recovered on 162 isolated occasions during the two lactation periods on the regular fortnightly examinations. In addition, 35 recoveries were made at supplementary examinations. Out of 163 of these isolations, Group II. of Minett *et al.* has been recovered on 44 occasions.

(*d*) The incidence of these infections was similar to that of the Group B streptococci but, except in one case, these streptococci did not produce persistent infections, and at no time did they produce mastitis.

9. (*a*) During the first lactation period, haemolytic staphylococci were recovered from the milk of 9 cows (30 per cent.) and 17 quarters (14 per cent.). They produced recurrent infections in 10 quarters and more persistent infections in 7. Of the 17 quarters infected, 6 developed clinical staphylococcal mastitis.

(*b*) In the second lactation period, haemolytic staphylococci were recovered from the milk of 14 cows (46 per cent.) and 22 quarters (18 per cent.). Recurrent infections occurred in 12 quarters, more persistent infections in 8, and in two staphylococci were found on a single occasion in each. Clinical mastitis was manifested in 6 quarters, in one of which the clinical symptoms continued from the first to the second lactation period.

10. "Non-haemolytic" micrococci were found to be common invaders of the udder.

(*a*) In the first lactation period, micrococci were recovered from the milk of 18 cows (60 per cent.) and 44 quarters (37 per cent.). Persistent infections occurred in 32 quarters, recurrent infection in 71, whilst in 4 the occurrence was occasional and in 1 it was transient.

(*b*) In the second lactation period, micrococci were recovered from the milk of 26 cows (86 per cent.) and 76 quarters (64 per cent.). Persistent infections occurred in 61 quarters, recurrent infection in 13, and in 2 quarters micrococci occurred on a single occasion in each.

11. With one exception, the herd was free from udder infections by corynebacteria. Anaerobic bacteria were not recovered from the milk of any of the cows.

12. *Str. agalactiae* was recovered from the faeces of 7 cows and from sores on the teats on two occasions.

13. Suckling calves appeared to have no appreciably beneficial or harmful effect as judged by the bacterial status of the udder. Over-stocking during the drying-off period tended to increase the bacterial counts in the milk.

14. Attempts to control the bacterial status of the udder by sealing the teats were unsuccessful in the few cases treated.

15. Systematic bacteriological examinations at fortnightly intervals during the first lactation period of 12 first-calf heifers in another herd yielded results comparable with those obtained in the experimental herd.

16. The clinical investigations carried out on the experimental herd and the observations made on infective and other abnormalities of the udder are outlined. Sores on the udders and teats were common and appeared to be of staphylococcal origin. Case reports are given of 3 cows which developed streptococcal and of 7 cows which developed staphylococcal mastitis during one or other, or both, lactation periods. Bacterial infections in the quarters had no appreciable effect on the yield of milk unless clinical symptoms developed. Clots were found frequently in the milk from sterile quarters but were somewhat more frequent from quarters in which bacteria had become established.

Hypertrophic verrucose lesions of the lining membrane of the teat canal were frequent in occurrence. Of the 203 quarters under observation in both the experimental and non-experimental sections of the herd, 39 developed these lesions. They did not appear to be of bacterial origin.

The development of mastitis was not correlated with the productiveness of the cow nor with the size of the teat orifice.

17. The cellular content of the milk from quarters which remained free from bacterial infection remained low. Of the samples from these quarters, 92 per cent. yielded cell counts below 100,000 per ml., and 8 per cent. did not exceed this count.

Infected quarters yielded cell counts of 200,000 per ml., or more, in a large proportion of samples. The proportion of samples from quarters with pure micrococcal infections was 59 per cent., from those with pure staphylococcal infections it was 83 per cent., and from those with streptococcal infections it was 84 per cent.

18. The laboratory methods employed for the bacteriological, serological, and cytological examinations are outlined.

19. Attention is drawn to the failure of the methods adopted to enable the establishment of a herd free from infections by *Str. agalactiae*. These preliminary results of the investigation are discussed. Attention is also drawn to the relatively high degree of infectivity of the micrococcus and the persistent character of the infections it has produced. The haemolytic staphylococcus has exhibited an infectivity almost as high and the infections have also been very persistent. Infections by *Str. agalactiae* have been more transient, and the results have failed to show that this streptococcus has a higher infectivity than the micrococcus or the staphylococcus.

The possible reasons for the failure of *Str. agalactiae* to produce the typical chronic streptococcal mastitis described by other workers are discussed. It is concluded that the possible absence of "epidemic strains" of the streptococcus, the absence of preliminary damage to the tissues of the udder by other infections on account of the youth of the cows, or both, may have been responsible for the more transient nature of the infections.

The results have shown that the infected udder is not the only reservoir of *Str. agalactiae*, and they suggest that methods of control of streptococcal mastitis based on the assumption that it is the only reservoir may meet with only partial success.

Development of the Flax Fibre Industry in Australia.*

An examination of the position of flax fibre within the Empire reveals a serious shortage in supply which is likely to be accentuated owing to the demand in the United Kingdom, brought about by the use of flax for war purposes.

The industry has been established on a small scale in Australia. Recent investigational work conducted by the Victorian Department of Agriculture on the growing of flax, and by the Council for Scientific and Industrial Research on the retting and processing of flax fibre, has reached a stage where the expansion of the industry on a commercial scale is warranted. Such an expansion might become the nucleus of a large and permanent Australian primary industry, with its attendant secondary industries. The United Kingdom Government has intimated that it would welcome any action taken in Australia for the extension of the industry, and that the United Kingdom would be able to absorb at world prices such quantities of flax as Australian growers may be able to offer.

It may be said with confidence that, with the use of improved varieties of fibre flax and the recent development of more efficient methods of retting and processing the fibre, the outlook for the flax fibre industry has completely altered during recent years.

1. World and Empire Production of Flax.

World production of fibre flax in 1937-38 amounted to 806,000 tons†. Of this the British Empire produced only 8,000 tons, or slightly less than 1 per cent. of the world total.

Soviet Russia is the principal producer of flax. Prior to 1914, Russia's annual production exceeded 700,000 tons, of which some 500,000 tons were exported. Practically the entire Russian output is now controlled and used by the Soviet, and supplies for Empire requirements must be obtained from Belgium, France, Northern Ireland, and the Baltic countries.

The United Kingdom imports amount to approximately 70,000 tons. Despite the various attempts to stimulate production in recent years, the Empire's flax resources are very small. Home grown flax amounts to less than 10 per cent. of the total requirements of the United Kingdom, and production in the Dominions is very small.

* Based on a paper prepared for a meeting of the Standing Committee on Agriculture, Hobart, 1940.

† Industrial Fibres—Report of Imperial Economic Committee, 1939.

2. Average Prices of Flax in London.

The average prices for commercial Livonian flax and Belgian water-retted flax, c.i.f. London, for the five years 1934-38, are summarized in the following table* :—

	Livonian ZK. (Sterling)	Belgian Water-retted (Sterling)
	£	£
1934	61 ..	90
1935	79 ..	100
1936	63 ..	96
1937	78 ..	112
1938	67 ..	111
Average prices (per ton) .. =	£70 ..	£102

3. Australian Requirements.

According to the Tariff Board (1938 enquiry), Australia's requirements of flax fibre approximated 1,370 tons, and linseed 22,300 tons per annum. It is probable that present requirements would exceed 1,500 tons of fibre and 25,000 tons of linseed.

The outlet for flax fibre will take several forms:—

(i) *Local.*—The use of flax yarns for threads and twine. Local manufactures of flax yarns have been of the order of £40,000 per annum. Flax yarns are now dutiable, and it is expected that this output will be greatly increased. Flax threads to the value of £50,000 sterling have until recently been imported. Recently, a large proportion of sewing twine has been made from flax as against hemp. This use of flax can be expanded considerably.

Australia uses about 13,000,000 square yards of canvas and duck. About 11,000,000 square yards of this are made from cotton, and 2,000,000 square yards from flax. Specialized plant is required for heavy canvas manufacture, and it seems probable that, with the big demand for the more simply manufactured cotton duck, it may not be feasible to manufacture flax canvas unless adequate local supplies of flax fibre were available.

(ii) *Export.*—The demand for flax fibre is so strong that the growing industry can develop on the basis of export, pending the enlargement of plant capable of producing canvas.

4. Flax Production and Processing.

(*a*) *Production.*—Flax fibre is obtained from the stems of the flax plant (*Linum usitatissimum*), which is cultivated over wide areas of the temperate regions of the world. A well distributed seasonal rainfall and a cool moist spring are essential for the development of fine long fibre. In the southern portions of Australia, fibre flax attains its best development in regions with an annual rainfall of 25 to 35 inches, and on fairly fertile, moist, well-drained soils. The normal height of fibre-growing varieties ranges from 2 ft. 9 in. to 3 ft. 6 in.

* Industrial Fibres—Report of Imperial Economic Committee, 1939.

In Australia, flax is grown in much the same way as a cereal crop, being sown at the rate of approximately 70 lbs. of seed per acre in the autumn with a seed drill, using superphosphate as a fertilizer. It is harvested with an ordinary binder in November-December. In Europe, flax is pulled, either by hand or by the use of specially constructed flax-pulling machinery. The fibre from pulled straw is claimed to be longer and of better quality than fibre obtained from straw cut with a binder. Flax-pulling machines have been tried in Victoria, but their use has not hitherto appealed to flax farmers. The economic aspects of harvesting the flax straw by the use of flax-pulling machines, and by the use of the binder, are worthy of further investigation.

During the past three years, the Victorian Department of Agriculture has conducted field experiments with improved varieties of flax. The influence of variety, rate of seeding, time of sowing, quantity of fertilizer, etc., on the yield of crop has been determined. These experiments have been conducted in five representative flax areas of the State, and the results should form a basis for the best cultural practice to be adopted in each locality. The results of the 1939 investigations are not yet available. The average yield of Liral Crown flax at all centres for seasons 1937-38 was 34 cwt. of flax straw per acre. This average yield may be regarded as highly satisfactory in view of the fact that the season 1938 was one of the driest ever recorded in Victoria.

(*b*) *Processing.*—The usual practice in Australia is to cut the flax crop with a binder just as the crop begins to turn colour and assume a brown appearance. The straw after drying in the stook is carted to the flax mill for processing. The processing of the straw involves three stages—(1) de-seeding of the sheaved straw; (2) retting of the de-seeded straw; (3) scutching of the dried retted straw. The seed is removed from the bolls or seed heads of the flax by passing the upper part of the sheaf, spread out fanwise, through heavy spring rollers, and winnowing the chaff from the seed.

Retting is now carried out by immersing the de-seeded straw in the sheaf in large concrete tanks filled with warm water, the temperature of which is controlled within narrow limits. During the process of retting, bacterial fermentation converts the gummy substances into soluble products easily removable by water. After retting, the straw is dried and scutched. The products from these operations are seed, fibre flax, flax tow, and chaff. Both seed and fibre are obtained from the linen flax plant in current agricultural practice.

With any extensive development of the flax fibre industry in Australia, provision should be made for producing pedigreed flax seed as an enterprise apart from the production of fibre. The surplus seed, other than that required for sowing, may be used for oil extraction mills, which already exist in Australia.

Linseed, however, is usually produced from specialized varieties with short branched stems. These varieties, while of high value for seed production, are of little or no commercial value for fibre production. Linseed varieties are being tested out by the New South Wales Department of Agriculture at the Rice Research Station near Leeton; preliminary results appear to be promising.

5. Present Position of the Flax Industry in Australia.

In Australia experiments have been conducted in flax culture, but only in Victoria has the crop persisted to any extent. The chief factors hitherto preventing the expansion of the fibre industry in Australia have been—

(i) Lack of suitable varieties of flax capable of yielding a high percentage of good quality fibre.

(ii) The high cost of production of the fibre after the crop is grown, owing to the amount of labour required in processing by the methods formerly in vogue.

(iii) The lack of scientific knowledge of controlled methods of retting and extracting the fibre from the straw.

(*a*) *Varieties of flax*.—The lack of suitable varieties capable of yielding a high percentage of good quality fibre has been overcome. The Linen Industries Research Association of Great Britain has devoted many years of intensive search to the production of improved varieties. The Association has developed improved varieties such as Liral Crown, which yield 50 to 60 per cent. more fibre than the ordinary commercial varieties formerly used. Moreover, the quality of the fibre of these improved varieties is of the highest grade. These improved varieties have been thoroughly tested in Australia and have given heavier yields of straw than the varieties formerly grown. Moreover, the percentage yield and quality of fibre have also been considerably higher than from varieties formerly in cultivation. This is an important economic factor in the development of the Australian flax industry.

(*b*) *High cost of production*.—Until comparatively recently, all flax straw in Australia was processed by dew-retting methods. This involved spreading the de-seeded flax straw out in layers in grass paddocks in the autumn, and allowing the straw to remain exposed to the action of dew and moisture for some weeks until the "retting" process had been completed. This process of retting involved much labour in carting, spreading, and turning the material in the field, and finally binding it in sheaves for carting back to the mill for scutching. As the retting process was entirely dependent on weather conditions, which varied widely during the season, it was practically impossible to secure a constant and uniform quality of processed fibre, and the proportion of tow to fibre was unduly high. Dew retting had the triple disadvantage of high labour costs, poor quality of fibre, and high proportion of the lower grade tow to fibre. Belgian water-retted flax has always enjoyed a substantial premium in the United Kingdom market over the dew-retted flaxes from the Baltic States.

The methods of scutching formerly in vogue were also very primitive and involved the use of much labour. Large automatic scutchers which greatly reduce the amount of hand labour and result in a more uniform quality of product and a higher percentage of linen fibre are now available for processing.

It is not a matter for surprise, therefore, that under dew-retting methods of processing, and the use of hand scutching, the industry made little progress in Australia.

(*c*) *Controlled retting methods.*—The lack of scientific knowledge of the methods of retting and extracting the fibre from the straw has been overcome by the investigations conducted in recent years by the Council for Scientific and Industrial Research. The work has been confined to problems of retting, which is the process by which the fibres are separated from the straw. The usual practice is to obtain the separation by the action of bacteria (which always accompany the straw) by soaking in warm water retting tanks maintained at an appropriate temperature. It was essential to work out in detail all the conditions of tank retting which will give the maximum yield of the highest quality straw in the shortest possible time. This work is complete, and the Council is now in a position to advise any interested bodies on these matters. It has been shown that, with suitable technical control, high grade fibre can be produced from Australian grown flax.

Having established this fact fully, it was then decided to attempt to devise an improved method of retting which would be quicker than the usual method of retting and subject to closer control than any process which depends on bacterial action. The Council has now devised a method of chemical retting which takes hours instead of days, and which produces a fibre which has been examined in England and valued at a price equal to that of the best quality flax. This chemical process has reached the stage when a semi-commercial pilot plant, on which accurate costing could be made, could be safely established, and it is hoped that it will be possible to do this in conjunction with the industry.

During the 1939 season, approximately 2,000 acres of flax were sown in Australia with improved varieties of flax developed by the Linen Industries Research Association. The initiative in securing this acreage of high quality flax was taken by Flax Fibres Pty. Ltd., of Melbourne. Controlled methods of tank retting have been worked out by the Council for Scientific and Industrial Research in association with Flax Fibres Pty. Ltd., at their Colac mill, and it has been demonstrated that a high grade uniform product can be produced on a commercial scale from Australian-grown flax.

The amount of labour associated with the scutching of the retted flax has been greatly reduced by the introduction into Australian practice of a Belgian automatic scutcher for processing the retted straw.

6. Possible Extension of the Industry in Australia.

As already stated, inquiries made from the United Kingdom authorities indicate that the Ministry of Supply would welcome any action taken in Australia for the extension of plant, and that the United Kingdom would be in a position to absorb at world prices such quantities of flax as Australian growers may be able to offer. There would therefore be no difficulty in marketing flax fibre produced in excess of Australia's requirements. At the present time, however, insufficient flax is produced to supply Australian needs.

The area sown to fibre flax in 1939 is estimated at approximately 2,000 acres. Practically the whole of this is the Improved Liral Crown variety. The seasonal conditions have been fairly favorable for the growth of the flax crop, and an average yield of 30 cwt. per acre might reasonably be expected. This would provide 3,000 tons of flax straw from which a minimum yield of 250 tons of flax seed suitable for

sowing might be expected. With a normal seeding of 70 lb. per acre this would provide sufficient seed for at least 8,000 acres of flax in 1940. Unless local supplies of Liral Crown seed are supplemented by imports of seed from abroad, or lower grades of seed are used, this acreage would represent approximately Australia's maximum area of flax for the 1940 season.

Existing milling facilities in Australia are sufficient to treat the produce of 2,000 acres of flax grown during the current season, and any further expansion of the industry would need extensions of existing plant or the provision of further processing mills at country centres. Modern methods of retting involve the use of large quantities of water and a satisfactory means for the disposal of the effluent. The bulky nature of the flax straw requires that it should be processed as near as possible to centres of production, in order that freight charges may be reduced to a minimum. Ten tons of de-seeded flax straw normally produce $1\frac{1}{2}$ to $1\frac{3}{4}$ tons of fibre and tow.

An economic unit for a milling plant would be a mill and rettery capable of being handled by one executive in a locality reasonably accessible to a farming area in which an average acreage of 1,200 to 1,500 acres of fibre flax (producing a total yield of 1,800 to 2,250 tons of straw) could be relied on as a permanent source of supply.

Flax should not be grown continuously on the same land, but in a three or four-course rotation with other crops or temporary pastures. To maintain an area of 1,200 to 1,500 acres of flax in a given district, a minimum area of 3,600 to 4,500 acres of cultivable land would be located at a centre where abundant water is available.

For the processing of the flax by water-retting methods, large quantities of water are necessary. A milling site, therefore, needs to be located at a centre where abundant water is available.

It has been demonstrated that the climate and soils of the Western District of Victoria, Gippsland, and the Kiewa Valley in the North-east are suited to the production of fibre flax. The northern areas of Tasmania have in the past grown good fibre flax, but farmers who have previously grown flax have suffered losses at the hands of flax companies with insufficient capital and lack of experience in modern methods of flax processing. Other possible areas for fibre flax production are the lower south-east of South Australia, and the higher rainfall areas in southern New South Wales, and possibly the south-western areas of Western Australia. The status of fibre flax on irrigation areas has yet to be determined.

Flax Fibres Pty. Ltd., of Victoria, possess flax treatment mills at Colac and Drouin. This Company has played a prominent part in the development of the fibre flax industry in Victoria during the past three years, and was responsible for the commercial use of Improved Liral Crown flax in Victoria.

The Fibre Committee of the Council for Scientific and Industrial Research has given consideration to the capital costs of establishing unit treatment mills based on a permanent supply of 1,200 to 1,500 acres of flax per annum. It is estimated that the capital cost, including provision of land, retting tanks, buildings, and equipment, including plant for drying retted straw, for handling the produce of 1,200 to 1,500 acres of flax under pre-war conditions, would be £12,500. In view of

the possibility of increased costs of machinery, materials, and plant since the outbreak of war, it would be safer to put this capital cost at £15,000. In addition, provision would be needed for working capital to finance the operation of such a mill pending the marketing of the products and the cash cost of purchasing flax straw from farmers on delivery to the mill. This amount is estimated at £5,000 per unit per annum, apart from the funds necessary for cash purchases of flax straw from farmers.

As already indicated, the present area under flax in Australia is 2,000 acres. If the area were increased to 8,000 acres in 1940 to make use of all available pedigree seed, it would be necessary to provide additional processing plant for treating the produce of 6,000 acres. With 1,200 acres as the minimum economic unit for a mill, the additional capital required to finance mill extensions and equipment would amount to approximately £75,000. In addition, £25,000 would be required for working capital—a total financial requirement of £100,000, apart from cost of purchases of flax straw.

An area of 8,000 acres might reasonably be expected to produce an average of 12,000 tons of flax straw per annum, which on processing might be expected to yield 1,000 tons of flax seed, 1,200 tons of fibre, and 600 tons of tow. This acreage would provide sufficient flax straw to meet Australia's present requirements of flax fibre and tow, but substantial additional areas would be required to provide for the requirements of flax canvas manufacture, as for export of surplus fibre to the United Kingdom.

Flax canvas is a necessity for many industries, and particularly concerns the Government Railways, tent and tarpaulin trades, the Defence Department, and the Marine Services. It is understood that flax fibre has nearly trebled in value in world markets since the war, and present indications are that prices may move to even higher levels in the event of a prolonged war.

7. Assistance to the Flax Industry.

In view of the shortage of flax fibre in the Empire, and in view of the fact that the excess demand brought about by curtailment of supplies from European countries and that its use for war purposes in Britain is likely to result in substantially higher prices, the present time is appropriate for considering the expansion of the industry in Australia.

The investigational work carried out by the Victorian Department of Agriculture on the growing of flax, and by the Council for Scientific and Industrial Research on the retting and processing of the fibre, has reached a stage at which the expansion of the industry appears to be warranted. The opportunity should be taken to provide long-range plans for the orderly development of the industry so that it will be technically efficient and capable of continuing as a permanent industry on a profitable basis.

Advantage should be taken of the high profits that are likely to accrue during the war period to amortise the capital necessary for the establishment of the industry, to create a reserve fund to continue payments to farmers for flax straw at a price level which would be attractive, and to provide for the development of scientific and technical research into problems of production and processing of flax.

The Australian Liaison Officer at the Royal Botanic Gardens, Kew.

Mr. C. T. White, Government Botanist, Queensland, who succeeded Mr. C. A. Gardner, Government Botanist, Western Australia, as Australian Liaison Officer at the Royal Botanic Gardens, Kew, England, recently returned to Australia. He has now submitted a brief report on which the article that follows is based.

The sending of Mr. Gardner and Mr. White to England was in accordance with a decision made at the Imperial Botanical Conference held in August, 1935; at that meeting a resolution was passed commending to the Government of the Commonwealth of Australia the importance of maintaining close liaison in botanical matters with the Royal Botanic Gardens, Kew, and urging the Government to consider favourably the appointment of an Australian systematic botanist to work at Kew for a period of at least two years in making a critical examination of the historic type specimens at Kew and at the British Museum, and determining current collections made in the Commonwealth and sent over to Kew for critical examination. It was further suggested by the Conference that at the expiry of the term of appointment the officer should be replaced by another botanist from Australia.

The basic idea of appointing such a liaison officer was to facilitate co-operation in botanical matters and to make the extensive botanical resources of the Gardens more readily and quickly available in Australia. Without such close co-operation a number of errors in the way of identification and description of species new to Australia could readily be made and in the past have been made. Similar arrangements to those outlined above for Australia have been existing between South Africa and Kew for some years past.

The whole proposal was subsequently approved by the Standing Committee on Agriculture and the Australian Agricultural Council, and Mr. C. A. Gardner, the first liaison officer appointed, left for Kew in February, 1937. He was succeeded two years later by Mr. White.

In Mr. White's report he indicates that he was able to accomplish much useful work. Several thousand specimens were taken over by him for comparison with type material at Kew and other institutions in Great Britain.

The Royal Botanic Gardens, which now cover nearly three hundred acres, consist of the gardens proper, the Joddrell Laboratory, four botanical museums, under which may be included the Marianne North Gallery of Paintings, and the Herbarium Library. It was in the last Department that the Australian liaison officer was established. The Herbarium is generally recognised as the most extensive in the world and is a model of arrangement. In spite of the size of the collections, individual plants are easy to find, and what is important, facilities are excellent for visitors to work in the Herbarium. The whole is under the direction of Sir Arthur Hill.

Mr. White expressed appreciation of the assistance afforded him by the Keeper of the Herbarium (Mr. A. D. Cotton) and other members of the Herbarium staff. He arrived at Kew on the 6th March, 1939,

and, as soon as his specimens were available, arranged them in botanical sequence and worked systematically through them, checking up with types. Up to the time of the outbreak of war, every specimen checked was mounted, and new species were described, but from that time onwards, only essential work was done, leaving details to be elaborated in Australia.

In addition to Kew, there are important Australian collections at the British Museum, the University of Cambridge, and the Linnean Society of London. Besides Robert Brown's types and those of Banks and Solander, the British Museum contains a complete set of Robert Brown's manuscripts, bound in order according to the Bentham and Hooker system of classification. These manuscripts, along with the types referred to, have now been transferred to a country locality for safe keeping. At the Linnean Society, Mr. White was able to consult Sir James E. Smith's types. The Smith Herbarium, though small, is of considerable importance to Australian botanists, as Sir James E. Smith described a number of Australian plants, especially from the neighbourhood of Port Jackson. The Smith collections have now been removed to the country along with the very valuable Linnean collections, which have been in the country since September, 1938.

Under normal conditions, Mr. S. T. Blake was to have followed Mr. White for the second year of the term, but owing to the international situation, Mr. Blake's visit may have to be postponed.

While at Kew, the Director (Sir Arthur Hill) discussed with Mr. White the very limited use which Australian botanists are making of the services of the liaison officer at Kew. This may be due to the fact that up to the present only senior officers have gone, and there has been a great deal of leeway to make up. In consequence, Australian botanists may have felt a little diffident about sending further material. Mr. White states that this was the case with himself when Mr. Gardner was there, because he knew that Mr. Gardner had taken over large collections, and had so much work to do on the plants of his own region that he did not like bothering him with other specimens. As the scheme progresses, however, and junior officers are sent, it is to be hoped that Australian botanists will make full use of the presence of an Australian botanist at Kew whose work it is to report on collections sent over, and especially to compare species of critical groups with type or co-type material.

Sir Arthur Hill again regretted that all Australian Herbaria did not make a point of mounting their specimens, and made a very strong plea that at least all type specimens should be mounted. This is especially desirable in a collection such as that in the National Herbarium at Melbourne, which is probably unrivalled in its wealth of type and other Australian material.

The Mechanization of the Council's Mailing List.

*By F. G. Nicholls, M.Sc.**

Summary.

The Council's publications deal with a wide variety of subjects, and their distribution presents a rather unique problem. The way in which a Class 2200 Addressograph machine was modified to include automatic electrical selection to solve this problem is described.

1. Introduction.

The extension of the Council's work into new fields, together with the fact that many of the existing investigations have reached the fruitful stage, has resulted in the last few years in a considerable increase in the number and variety of publications issued. These publications deal with subjects as widely separated as animal health, forest products, and radio research. More and more organizations and people have asked for this literature, until now the mailing list includes over 5,000 names.

To avoid waste, it is obviously necessary to see that all papers issued are sent to people who are particularly interested in them and who can make good use of them; naturally not everyone is interested in all the subjects with which the Council is concerned. For these reasons, the mailing list was originally sub-divided into sections including "all publications", "annual report", "journal", "soils", "plant problems", "animal health", and "food preservation".

As the Council's work extended, new sections and sub-sections were created, and in 1938 the need for revision of the whole mailing list became acute. As one step in that revision, a questionnaire form was distributed early in that year with the object of ascertaining the correct names and addresses of those who received the Council's publications and the subjects in which they were interested. This form (see Fig. 2) included some 50 categories of subjects on which the Council might issue publications. When the completed forms were received, the whole question of despatch was reviewed, and it was felt that some mechanical system should be adopted.

Prior to the above revision, two sections of the list were much larger than the others; they were—(i) the journal list, and (ii) the list of those who received everything published, i.e., the "general mailing list"†. These sections were held as separate units on stencils and envelopes were printed on an Elliott addressing machine operated by hand. The remainder of the sections were arranged on cards with coloured metal signals attached to their top edges to indicate the main sections. When any publication was issued, it was necessary first to run off envelopes (numbering about 1,000) from the "general mailing list" stencils. In addition, it was necessary to pick out from the cards the names of those interested in the particular subject dealt with and to type these names (generally about 500) on to envelopes. This process was not only time-consuming, but it was subject to two sources

* An officer of the Information Section, C.S.I.R.

† In the subsequent paragraphs, this list is referred to as "all publications".

of error, namely errors in copying and errors of selection. The metal signals along the top edge of the card introduced a further difficulty. They were cumbersome and prevented the cards from being turned over rapidly without disturbing their order.

2. The Problem.

One suggested method of mechanization was to provide a set of stencils for each section. There were many objections to this scheme, the main one being the fact that usually a publication is of diverse interest and may, therefore, be sent out on more than one section of the list. For example, a publication on pastures might be distributed using the lists of addressees interested in sheep, cattle, pastures, and plant breeding. In these cases many people would have their names on stencils in each of these sections and thus would receive duplicate, or in extreme cases four or five copies of the one paper. Such a method would mean, too, that one person might easily require eight or more stencils if he was interested, as many are, in several different sections of the mailing list. Finally, the names and addresses are continually changing and the work of checking and correcting the list would be multiplied many times. Incidentally, these considerations finally led to the decision to aim at producing one list arranged in alphabetical or other convenient order and then to pick out addresses from this list mechanically.

Briefly, the problem confronting the Council was to arrange for an individual to be able to choose to receive publications dealing with any number of subjects up to 50 and for it to be possible to select automatically persons interested in a publication which might deal with several of these subjects. The list of names must be arranged so that changes of address might be readily effected and so that it would be possible to eliminate certain groups of addressees, if it was desired to issue a publication only to a selected few.

A survey of commercial addressing machines indicated that, without modification, none of them were suitable for the purpose, and it was finally decided that the Addressograph machine, Class 2200, manufactured by American and British interests, would be the most suitable for conversion, although a German machine, the Adrema, was also a possibility. An Addressograph machine was accordingly obtained and modified as described below.

3. Mechanical Selection.

Before describing the changes which were made in the selection mechanism of this machine, it might clarify the position if this problem of selection were considered more fully and then the deficiencies of existing apparatus discussed in detail.

In the Addressograph and Adrema addressing machines, the names and addresses are embossed on zinc plates, and these plates are then filed in order, generally alphabetical, in metal cabinets. To print, the plates are placed in the hopper of the machine, and they then pass through the bed of the machine and back into their filing tray still in their original order. As the plates go through the machine, they pass under a wide typewriter ribbon. If the plate is to print, a rubber

platen presses the envelope on to the ribbon and type plate, thus producing an impression of the address. The motion of this platen is governed by a clutch which is itself under the control of the selection mechanism. Both machines are driven by electric motors, but in the Addressograph the connexion between clutch and selection mechanism is purely mechanical, while in the Adrema this connexion is made through an electrical circuit.

Addressograph printing plates have a series of sockets at the top, and removable metal tabs inserted in these sockets enable up to 24 classifications to be obtained (see Fig. 1).

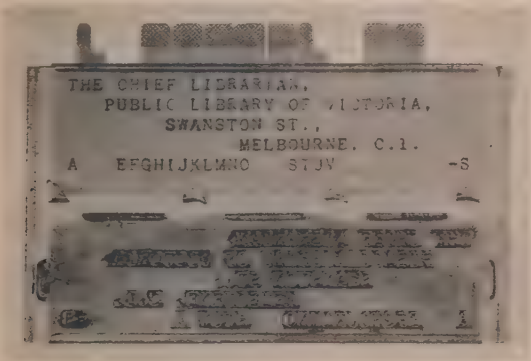

Fig. 1.—Addressograph Plate showing Selector Tabs arranged for an Addressee who receives all publications.

The essential part of the selection mechanism is the selector bar which has holes corresponding to the 24 tabbing positions on the printing plate. Steel pins can be placed in one or more of these holes as desired, and these selector pins then project downward like the teeth of a comb. To select any particular classification, a pin is placed in a hole of the selector bar corresponding to the position of the tab reserved for that class on the printing plate. The selector bar moves downward each time a printing plate passes under it on its way to the printing point. When a pin in the selector bar strikes a tab on the printing plate, the Addressograph will print an impression from that plate when it reaches the printing point of the machine. If the pin does not strike a tab, the plate will skip through without printing.

At first sight it might seem that further classifications over and above the 24 would be possible by using combinations of tabs (and pins). This, however, is not so. For instance, say the first three tabbing positions (and pins) are A (sheep), B (cattle), and C (pigs). The possible combinations of pins are thus:—

(1) A	(5) AC
(2) B	(6) BC
(3) C	(7) ABC
(4) AB	

It will be seen that Combinations (4), (5), (6), and (7) will only result in selection of various combinations of people interested in sheep, cattle, and pigs, and that they do not form new sections.

This mechanical method of selection would not suffice for the purpose under discussion, as it provides a maximum of 24 independent classes and at least 50 are needed. Several other limitations will become obvious after consideration of the following paragraphs.

Although the Adrema plates also carry tabs, these tabs play no part in selection—they are merely indexing guides. Selection is accomplished by means of embossed pips, embossed on the zinc plate at the same time as the name and address. These pips operate a series of electrical contacts as the plate passes the selection mechanism, and, provided the contacts closed are those which the machine is set to select, the plate prints; otherwise it skips through unprinted. The introduction of this electrical selection system opens up new possibilities. We can now choose to work with combinations of pips and in this way to extend greatly the number of classes available. Pips may be embossed in thirteen different positions providing thirteen classes. If the electrical circuit is arranged so that two pairs of contacts must close simultaneously before printing occurs, this number is extended to a maximum of 6 x 7, i.e., 42 classes. With three pairs of contacts closing together, we obtain 4 x 4 x 5, i.e., 80 classes, and so on. However, all of these classes cannot be made available to an individual by using a single plate—to provide 42 classes, six plates are required, and sixteen plates per person would be necessary to make each one of 80 classes available to each person.

4. Electrical Selection Applied to Addressograph.

An electrical selection mechanism has now been developed by the writer and incorporated in the Class 2200 Addressograph machine. This system can operate using two or more pairs of contacts for each selection. If two pairs are used, the 24 classes can be extended to a maximum of $(\frac{24}{2})^2$, i.e., 144. If three pairs of contacts are used the maximum becomes $(\frac{24}{3})^3$, i.e., 512, and so on. Although 144 classes are available when using two pairs of contacts in combination for each selection, twelve plates would be needed to make all of these classes available to one person. By careful grouping of classes and subjects, and by taking advantage of the fact that some classes include others as sub-classes, it has been possible to arrange matters so that all of the 50 odd classes are provided for with a maximum of four plates per person. The groups have been made so that only a small percentage of people need more than one plate. In practice, ten pins of the 24 are used singly and the remainder in combinations of two. For some of the special purposes discussed later, combinations of three pins are involved in selection.

A copy of the questionnaire form referred to above is shown in Fig. 2. The 24 tabbing sockets have been designated by the letters A to X and the letters inserted alongside each section in the questionnaire form

Address at present on our list.

Name (and Title) ____________

(Revised Address to which it is desired Publications should be sent) ____________

1. **All Publications** ______ EV
   EFGHIJKLMNOSTUV
2. **Annual Report** F ___
3. **Journal** ______ G
4. **Soils** ______ H
5. **Fisheries** ______ EO
6. **Radio Research** ______ ES
7. **Mining and Metallurgy** ______ ET
8. **Other Industries** ______ EU

Note re Sections 9 and 10:—

The "Special Aspect" subdivisions are intended mainly for scientific investigators who are interested in, say, breeding only, or diseases only, irrespective of the nature of the plant or animal concerned. In such cases, only mark the "Special Aspect" portions of 9 and 10. If other sections are also marked, it will be assumed that only the "Special Aspect" of that particular plant or animal is required.

9. **Animal Problems**—
   - (*a*) All Publications ______ I
   - (*b*) Cattle (dairy) ______ BO
   - (*c*) Cattle (beef) ______ BP
   - (*d*) Sheep ______ BQ
   - (*e*) Horses ______ BR
   - (*f*) Pigs ______ BS
   - (*g*) Special Aspects:—
     - (i) Diseases and Pests ______
     - (ii) Breeding ______
     - (iii) Feeding ______
     - (iv) Products ______

10. **Plant Problems**—
    - (*a*) All Publications ______ J
    - (*b*) Pastures ______ BU
    - (*c*) Field Crops ______ BV
    - (*d*) Horticulture ______ CO
    - (*e*) Tobacco ______ CP
    - (*f*) Weeds ______ BW
    - (*g*) Fibre Plants ______ CQ
    - (*h*) Special Aspects:
      - (i) Diseases ______
      - (ii) Pests (insects, &c.) ______
      - (iii) Introduction ______
      - (iv) Breeding ______

11. **Entomological Problems**—
    - (*a*) All Publications ______ K
    - (*b*) Forest and Timber Pests DO
    - (*c*) Special Aspects.
      - (i) Systematic ______
      - (ii) Insecticides ______ DQ
      - (iii) Biological control ______ DR

    (Entomological publications dealing with the pests of a particular plant or animal, &c., will also be sent out on lists under 9 and 10 &c.)

12. **Irrigation Settlement Problems**—
    - (*a*) All Publications ______ L
    - (*b*) Vines ______ CS
    - (*c*) Citrus ______ CT
    - (*d*) Pastures ______ CU

13. **Forest Products**—
    - (*a*) All Publications ______ M
    - (*b*) Chemical ______ DS
    - (*c*) Wood Anatomy ______ DT
    - (*d*) Preservation ______ DU
    - (*e*) Seasoning ______ DU
    - (*f*) Utilization ______ DV
    - (*g*) Tanning ______ DW
    - (*h*) Paper ______ DP

14. **Food Preservation and Transport**—
    - (*a*) All Publications ______ N
    - (*b*) Meat ______ BT
    - (*c*) Fish ______ EP
    - (*d*) Poultry ______ EQ
    - (*e*) Fruit and Vegetables ______ CV
    - (*f*) Physics of Storage and Transport ______ ER

C.1858.

Fig. 2.—Questionnaire Form Showing Tabbing Positions for each Subject.

refer to the arrangement of metal tabs provided for that section. The main sections, namely, "annual report", "journal", 'soils", "animal health", &c., have been assigned the single letters F—N inclusive.

Sub-sections have been assigned combinations of letters, and related sections have been grouped so that one letter is common to them. Thus the sub-sections of animal health are represented by cattle (dairy), BO, cattle (beef), BP, sheep, BQ, horses, BR, and pigs, BS; preservation and transport of meat by BT; and pastures, field crops, and weeds by BU, BV, and BW, respectively. Similarly, the division of the sections of entomology is made by combining letter D with O, Q, and R. Each addressee on the "all publications" portion of the list is assigned a plate carrying the letters E F G H I J K L M N O S T U V, the combination EV distinguishing this plate for special purposes.

The "special aspects" divisions of the sections "animal problems" and "plant problems" were included to cater for research workers and others who were interested in certain restricted fields, and who might be interested in, say, diseases and pests of all animals or of sheep or cattle only. These lists have been held as separate units apart from the main list, and the classes have been assigned tabs in rather different fashion as set out below:—

Animal Problems.		*Plant Problems.*	
Diseases and Pests ..	B	Diseases	B
Breeding	C	Pests (insects, &c.) ..	C
Feeding	D	Introduction ..	D
Products	E	Breeding	E
Cattle (dairy) ..	O	Pastures	U
Cattle (beef) ..	P	Field crops.. ..	V
Sheep	Q	Horticulture ..	O
Horses	R	Tobacco	P
Pigs	S	Weeds	W
Other animals ..	T	Fibre plants ..	Q
		Other plants ..	R

Selection is accomplished by using one or more of the first group of positions B, C, D and E with one or more of the second group O—W to provide subjects, such as:

Breeding of sheep	CQ
Breeding of pigs	CS
Feeding of cattle (dairy and beef)	DOP
Diseases and pests of pastures and field crops ..	BCUV

A further departure from the aim of making only one list has been made in the case of the list of those who receive more than one copy of various publications. The plates in the four parts of the complete mailing list—"main section", "bulk list", "special aspects of animal problems" and "special aspects of plant problems" have been arranged

in the same sequence, and plates of each group are provided with index cards of different colours and each group further distinguished by a code letter. These code letters enable any one checking in one list to know whether a name occurs also in any of the other lists.

The selector bar of the Class 2200 Addressograph machine was replaced by a bar carrying 24 metal pins arranged so that pressure on a pin closed a pair of electrical contacts set on an insulating block directly above the pins. Wires from these contacts connect with 24 sets of sockets on the switchboard shown in Fig. 3. For convenience these sockets are labelled A—X corresponding with the sequence of 24 tabbing positions on the Addressograph plates. The clutch mechanism has been fitted with a solenoid arranged so that the clutch is brought to the printing position only when the solenoid is energized. Details of the circuit arrangements are shown in Figs. 4 and 5.

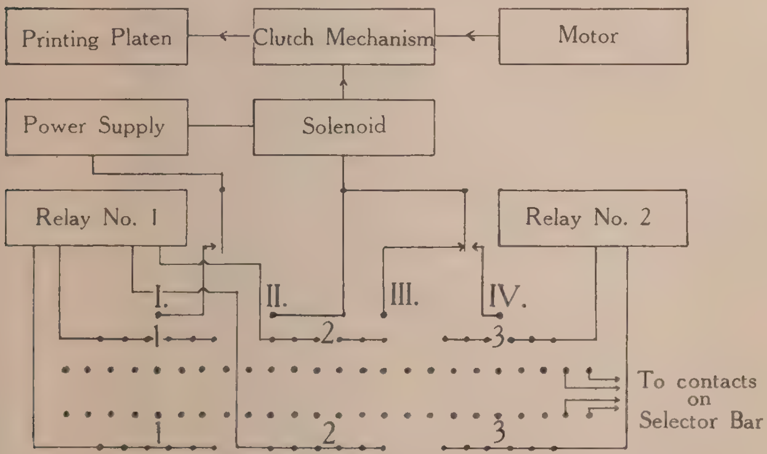

FIG. 4.—Block Diagram showing Function of Various Portions of Selection Mechanism.

Direct current to operate the relays and solenoid is provided by small transformers and metal rectifiers, the E.M.F. being of the order of 20 volts. For normal working, socket I is connected with socket II and then the solenoid is controlled by relay 1. The coils of this relay are energized if connexion is made between sockets of groups 1 and 1 or 2 and 2. Leads may be arranged so that one pair of contacts or any number of pairs must close to complete these circuits. Relay 2 comes into operation when socket II is connected to either socket III or socket IV. The coils of this relay are energized when connexion is made between sockets of group 3 and 3.

Some examples will indicate why this arrangement has been adopted. Suppose that a publication deals with tobacco (Class CP); it naturally also falls into the section dealing with plant problems as a whole (Class J), and hence might be designated by the letters J and CP. Plugs are

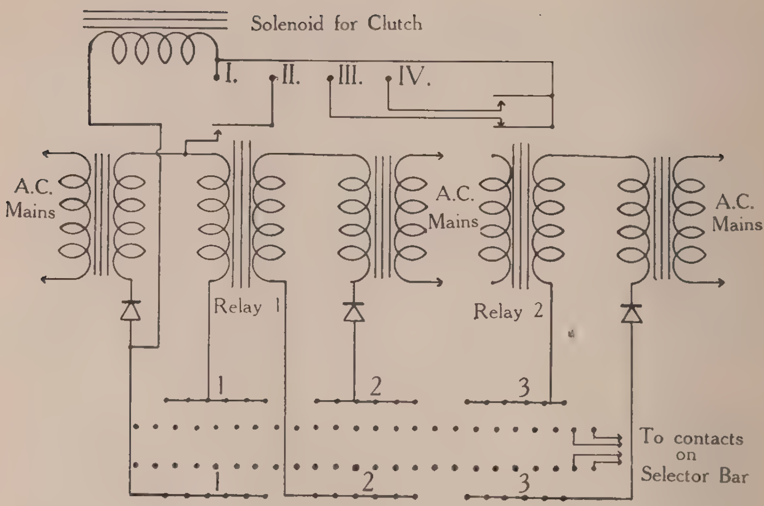

FIG. 5.—Circuit Diagram of Selection Mechanism.

inserted in the switchboard to connect I to II, a socket of the upper row marked 1 to the upper socket of J, the lower row marked 1 to the lower socket of J, a socket of the upper row marked 1 to one contact C, other side of C to one side of P, other side of P back to lower row 1; then if contacts J are closed or else C and P simultaneously, 1 is connected to 1, the solenoid is energized, and the machine prints.

Again, if two publications are to be issued at the same time they can go out in the same envelope to all who receive "all publications," thus effecting a saving in envelopes and handling. However, this necessitates passing the plates through the machine three times instead of two:—first, those who receive "all publications" are picked out by connecting 1 to E, E to V, V to 1, and I to II. On the second and third runs, the machine is set for the particular subjects with which the publications deal, and in addition connexions are made 3 to E, E to V, V to 3, and II to III. Now, when plates carrying EV pass through the machine, relay 2 is energized, it opens the contacts connected to III and the plate does not print even though relay 1 closes.

Although the results of major investigations carried out by the Council are published in its series of Bulletins and Pamphlets, other results, e.g. progress reports and results of a preliminary nature, are dealt with in the quarterly Journal. Naturally if a person asks for all the Council publishes on, say, plant problems, the information supplied to him will be incomplete unless reprints of Journal articles are sent as well as Bulletins and Pamphlets. So that reprints may be sent to those who do not receive the Journal, each plate belonging to this group of addressees carries a tab in the X position. If reprints are to be issued, the letters for the subject are set up as usual and then 3 to X,

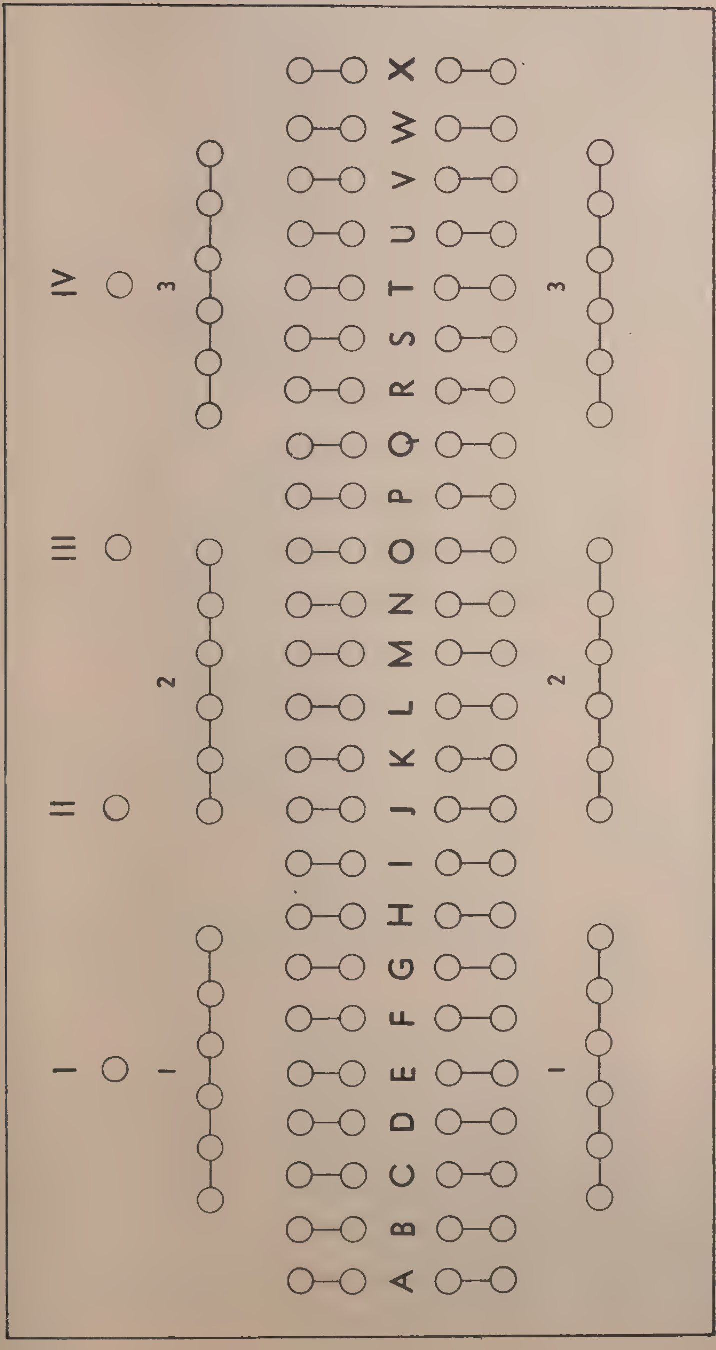

Fig. 3.—Selector Switchboard.

X to 3, and II to IV. In this case only those plates which carry X as well as the subject letters are printed, because until relay 2 is closed the solenoid cannot be energized even if relay 1 is operated.

5. Arrangement of Address Plates.

No separate index is needed with the Addressograph plate—each metal frame carries not only the zinc printing plate and selector tabs but a card printed from the zinc plate making the name and address clearly visible and enabling the plate to act as an index card. For this index to be of maximum value, the plates need to be arranged in a definite order. Some thought was given to the best method of arranging this material, special attention being given to ease of checking and to the possibility of printing lists for special purposes, such as would be necessary if a publication was of interest, say, only to schools or universities. The two major divisions, Australia and Overseas, have been further subdivided as follows:—

In the overseas section the address plates are grouped according to the continent, then the country, and finally the town in which the recipient resides. This holds with one exception—Great Britain—which is dealt with as a separate group. The names of all institutes, &c., have been translated into English and the names of towns and countries have been given in the English form. This enables checking to be carried out more rapidly and enables those interested in sending publications to workers in other countries to see at a glance the type of institute, &c., involved. It also enables abbreviations to be made in a standard way and conforms with international postal regulations.

The Australian section is divided into States, and then into these groups—Commonwealth Departments, State Departments, municipal offices, institutions (including schools, universities, overseas governmental representatives, societies, &c.), commercial organizations and private individuals. This last group contains only those persons who receive publications at their home address.

Abbreviations and the form of the address are dictated by space restrictions on the Addressograph plate, which limit all addresses to four lines, each not exceeding 33 spaces; the fifth line has been used to record the tabbing position letters A—X and also the previously mentioned code letters.

6. Other Uses of Machine.

This machine is also available to do work other than printing envelopes for despatching publications. It is useful in printing small stocks of envelopes addressed to government departments and the various laboratories of the Council which receive correspondence from head office each day. It has been suggested that the machine might print library catalogue cards, and that a Catalogue of Scientific Periodicals in Australian libraries could be issued on cards in this way.

Many other possible uses, including the printing of salary cheques and periodical library routeing slips, will be investigated in the near future.

7. Acknowledgments.

This problem was suggested to me by Mr. G. A. Cook, Assistant Secretary of the Council and Officer-in-Charge of its Information Section; I wish to express my thanks to him for many helpful suggestions throughout the progress of the work and during the task of compiling this record.

My thanks are also due to Mr. G. A. Cummins and Mr. D. Hill, of the staff of Stott and Hoare Pty. Ltd. and especially to Mr. D. Mansfield, who carried out the work of converting the Addressograph machine. I would also like to thank Mr. G. J. P. Tily, of the Postmaster-General's Department, for helpful advice, and Mr. A. A. C. Carter, of the Chemistry Department of the University of Melbourne, who gave me a great deal of assistance with the design and construction of the new selector bar.

Contributions to the Study of the Cell Wall.

I. Methods for Demonstrating Lignin Distribution in Wood.

By H. E. Dadswell, M.Sc., A.A.C.I. and Dorothie J. Ellis, B.Sc.†*

Summary.

1. Methods have been described for the study of the lignin pattern in the secondary wall of both coniferous and dicotyledonous woods; in the survey, normal and compression wood of numerous conifers and a wide range of tropical and temperate dicotyledonous woods, many Australian, have been employed.

2. The methods involved treatment of thin cross and tangential sections with 72 per cent. sulphuric acid; in some cases the sections were pretreated with a solution of iodine in potassium iodide; gentle warming of the slide was found essential in order to reveal the cell wall patterns with any degree of clarity.

3. It was found to be a comparatively simple matter to show cell wall lignin patterns in the case of a number of the species investigated, somewhat more difficult in others, and in a number of instances no cell wall pattern could be demonstrated.

4. The degree of lignification as indicated by the cell wall lignin pattern was correlated with that supposedly revealed by staining reactions using safranin and light green; there appeared to be a high degree of correlation between staining indications of the cell wall lignification and presence of cell wall lignin pattern.

5. In those species in which a lignin pattern was observed in cross section, the pattern was predominantly radio-concentric in nature; exceptions to this were found with compression wood tracheids and anomalous fibres from several dicotyledonous woods.

6. The importance of the work as a starting point for numerous additional investigations has been stressed.

1. Introduction.

It is significant that for many years a majority of botanists and, indeed, most botanical textbooks, have referred to the "lignified" secondary wall of plant tissues, basing conclusions as to the chemical nature of the cell walls only on the results of staining reactions. On the other hand, chemists and some botanists have been rigorously opposed to such methods of determining the constituents of the plant cell wall and have indicated their belief that staining reagents reveal the physical rather than the chemical nature of the cell wall. In 1928, Harlow (9) published the results of investigations on the reliability of staining reagents in micro-chemical studies of plant cell walls. He concluded that staining reagents in general were unreliable as specific indicators of the chemical components of the cell wall. Attacking the problem from the purely chemical point of view, Ritter (14) used a cellulose solvent, namely 72 per cent. sulphuric acid, on thin cross sections of wood; he observed the results microscopically. His work demonstrated the fact that by far the greatest proportion of the lignin present may be found in the middle lamella zone, although later he recorded (15) the presence of small amounts of cell wall lignin, but he could not, from the nature of his experiments, indicate the position from which this was derived.

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Harlow (8) investigated the secondary and tertiary layers of the cell walls of xylem, and reported that those of certain dicotyledons leave no coherent structural residue when treated with 72 per cent. sulphuric acid, whereas others leave compact residues such as have been considered typical of conifers. He reached the conclusion that the secondary walls of the xylem of softwoods are appreciably lignified, while those of hardwoods, with a few exceptions, contain practically no lignin. Bailey and Kerr (1 and 2), in their work on the visible structure of the secondary wall, have investigated microscopically the nature and pattern of the lignin residues of the cell wall. In the case of certain tropical hardwoods with thick cell walls, the lignin residue of the wall was revealed by treatment of cross sections with 72 per cent. sulphuric acid and subsequent staining with Haidenhaim's haematoxylon. The acid caused considerable swelling of the secondary walls, and, when the cellulose had dissolved, a fine, distinct, lignin pattern which was accentuated by the staining remained. In the normal tracheids of a number of softwoods and in the thick walled fibres of many hardwoods, the pattern was definitely radio-concentric, but in certain other cases it was more clearly radial and somewhat similar to that previously observed by Dadswell (7) in cell walls of a particular sample of jarrah (*Eucalyptus marginata*). These experiments of Bailey and Kerr indicated that with most coniferous woods it is possible to show the cell wall lignin pattern by the treatment of thin cross sections with 72 per cent. sulphuric acid. On the other hand, results with the dicotyledonous woods varied and fell into one of three classes, namely, (*a*) with coherent structural residues after direct treatment with 72 per cent. sulphuric acid, (*b*) with residues which appeared as fine granular material unless the sections had been given pretreatment with vanillin before the 72 per cent. sulphuric acid treatment, (*c*) with no definite pattern. The interesting point is that the observations of Harlow and Bailey and Kerr show that species of the temperate zones have unlignified or, at most, lightly lignified walls, whereas the timbers of the tropics appear to have a definite coherent lignin pattern in the secondary wall.

The question of the degree of lignification of the secondary wall is of definite practical importance, since several workers have indicated a possible correlation between lignin content and mechanical properties. Dadswell and Hawley (6) reported an abnormally high lignin content in certain brittle specimens of oak. Clarke (4) has pointed out that tropical timbers are in general weaker in impact bending, but stronger in compression parallel to the grain, than temperate zone timbers of the same specific gravity; from the results of staining reactions on the secondary walls, he has concluded that the tropical timbers are more heavily "lignified" than temperate zone timbers. He points out that various workers have demonstrated that staining reactions do not yield a reliable indication of chemical composition, but, at the same time, he stresses the fact that the staining methods he used (traditional lignin reagents of the botanist) have revealed the presence of some material or some condition of the cell wall which is correlated with the properties of the timber. His observations agree with those of Bailey and Kerr who definitely observed lignin residues in the secondary walls of tropical species but have not yet reported methods for studying the cell walls of the lightly lignified dicotyledonous

woods from the temperate regions. Jaccard (11) has referred to the greater degree of lignification in the cell walls of plants growing in dry, tropical zones. One important point still remains to be clarified. Although a great number of tropical timber species have thick-walled fibres, there are a number of species with thin-walled fibres occurring in tropical zones. Do the fibres of these species show definite coherent lignin patterns or are they more like the thin-walled species of the temperate regions? In other words, is not the degree of lignification more closely related to cell wall thickness than to climatic zones in which species are grown?

In the study of the timbers of any region, a knowledge of the distribution of lignin and of its effect on mechanical as well as pulping properties is of fundamental importance. Therefore, numerous experiments have been carried out with various Australian species in order to develop rapid and certain routine methods of showing the extent and arrangement of the cell wall lignin. It was considered essential to have available such methods before proceeding to the investigation of the effect of various chemicals on the lignin. It was found extremely difficult to duplicate Bailey and Kerr's procedure for revealing the lignin pattern either by the staining of the residue with Haidenhaim's haematoxylon or by the pretreatment in a solution of vanillin. It was therefore necessary to develop and standardize other procedures. For comparative purposes, several of the tropical species used by Bailey and Kerr and certain temperate zone species referred to by Clarke were included in the investigation. Various Australian species were selected for examination on the basis of thick fibre walls, thin fibre walls, impact strength, and probable pulping importance.

2. Material.

In the experiments to be described, thin cross sections 15 to 20 μ in thickness were utilized, and these were cut from the following species:—

AUSTRALIAN:

Acacia dealbata Link—Fibre walls thin, some gelatinous.

Acacia penninervis Sieb.*—Fibre walls thin, some gelatinous.

Ackama muelleri Bentham—Fibre walls thick.

Acradenia frankliniae Kipp.*—Thickness of fibre wall equal to or slightly greater than diameter of lumen.

Ailanthus imberbiflora F. v. M.—Fibre walls thin.

Aphananthe philippinensis Planchon.*—Thickness of fibre walls approximately equal to diameter of lumen, some gelatinous fibres.

Cardwellia sublimis F. v. M.—Thickness of fibre walls less than or approximately equal to diameter of lumen.

Cinnamomum oliveri F. M. Bailey—Fibre walls thin, some gelatinous.

Doryphora sassafras Endl.—Fibre walls thick.

Elaeocarpus grandis F. v. M.—Fibre walls thin.

Embothrium wickhami Hill and F. v. M.—Fibre walls thin.

Eucalyptus astringens Maiden.*—Fibre walls thick.

Eucalyptus diversicolor F. v. M.—Thickness of fibre walls approximately equal to diameter of lumen.

Eucalyptus marginata Sm.—Thickness of fibre walls approximately equal to diameter of lumen.

Eucalyptus obliqua L'Herit—Fibre walls in late wood thick, in early wood thin to medium.

Eucalyptus regnans F. v. M.—Fibre walls in early wood thin, in late wood medium to thick.

Euroschinus falcatus Hook—Fibre walls thin, some gelatinous.

Geissois benthami F. v. M.—Fibre walls thick.

Gmelina leichhardtii F. v. M.—Fibre walls thin.

Litsea reticulata Benth.—Fibre walls thin, some gelatinous.

Melia dubia Cav.—Fibre walls thin.

Pseudomorus brunoniana Bur.*—Thickness of fibre walls approximately equal to diameter of lumen, many gelatinous fibres.

Schizomeria ovata D. Don.—Fibre walls thick.

Sideroxylon australe Benth. and Hook.—Fibre walls thick.

Villaresia moorei F. v. M.—Fibre walls thick.

FOREIGN:

(*a*) From the Dutch East Indies—

Castanea tunggurut Bl.—Thickness of fibre wall approximately equal to the diameter of the lumen.
Homalium foetidum Benth.—Fibre walls thick.
Lophopetalum sp.—Fibre walls thin.
Tetramerista glabra Miq.—Fibre walls thick.
Urandra corniculata Foxw.—Fibre walls thick.

(*b*) From Kenya—

Casearia battiscombei Fries—Fibre walls thick, some gelatinous.

(*c*) From Northern Europe—

Aesculus hippocastanum *L.*—Fibre walls thin.
Castanea sativa Mill.—Fibre walls thin.
Fraxinus excelsior L.*—Fibre walls thin.
Salix nigra Marsh.—Fibre walls thin.

(*d*) From North America—

Betula papyrifera Marsh.—Fibre walls thin.
Hicoria ovata Vrit.*—Fibre walls thin.

CONIFEROUS WOODS:

Araucaria cunninghamii Ait. (Australian)—Compression and normal wood.

Pinus radiata D. Don (grown in Australia)—Compression and normal wood.

Podocarpus amara Bl. (Dutch East Indies).

Pseudotsuga taxifolia (La Marck) Britton, North America.

Tsuga heterophylla Sarg.—Compression and normal wood.

NOTES.—(1) Those species marked * were selected for examination because of their high shock-resistance properties.

(2) Thickness of cell wall determined approximately by microscopic inspection of cross sections at 400 magnifications: fibre walls termed thin where width from lumen to lumen of adjacent fibres less than diameter of lumen, and thick when greater than diameter of lumen.

3. Experimental.

In all cases, 72 per cent. sulphuric acid was used as the cellulose solvent, and the completion of the reaction was checked by examination of the sections (in the acid on the microscope slide) under polarized light. When the anisotropy of the outer layers of the secondary wall could no longer be detected, the reaction was considered complete and the residue taken as lignin (plus in certain cases cell contents which were insoluble in the acid). During the action of the acid the cell walls swell tremendously. To minimize the twisting and buckling of the sections thus occasioned, they were first cut on the microscope slide into very small squares of 2 to 3 mm., which were separated somewhat from each other on the slide.

Results with acid treatment alone were not outstanding. With the coniferous woods, the lignin from the intercellular zone was left more or less intact in the form of a fine network as the secondary walls swelled into the lumina of the tracheids, before slowly dissolving; cell wall lignin was apparently present, but no definite pattern could be detected. In the case of practically all the dicotyledonous woods examined, the enormous swelling of the secondary walls rapidly broke up the lignin network (compare Harlow (8), Ritter (14)) destroying any cell wall pattern that might have been present and leaving only an indeterminate mass of lignin (except in the neighbourhood of vessels and rays which seemed to be more heavily lignified and so retained their original size and shape). Some indications of lignin pattern in the cell wall were obtained with sections from *Tetramerista glabra*, *Homalium foetidum*, and *Urandra corniculata*, tropical species investigated by Bailey and Kerr, and very faint indications with the Australian species *Villaresia moorei*, *Ackama muelleri*, and *Sideroxylon australe*.

In 1931, Dadswell (7) reported that some cell wall lignin pattern could be observed in cross sections of jarrah which had been treated on a microscope slide with 72 per cent. sulphuric acid, the slide being slightly warmed. Employing the same procedure a definite cell wall lignin pattern was obtained in the case of sections of *Tetramerista glabra* and *Homalium foetidum* (see Figs. 1 and 3*), two species used by Bailey and Kerr in their investigations and with which they had obtained excellent results by means of their staining technique. Since it was found possible to duplicate the results of Bailey and Kerr by this means, the heating technique was applied generally and found to work exceptionally well with the various coniferous woods examined and with several of the Australian dicotyledonous woods, although not so successfully in a number of other cases.

Pre-treatment of the cross sections with alcoholic solutions of vanillin as carried out by Bailey and Kerr prior to the acid treatment did not prove successful in revealing the lignin pattern in those cases where the heating treatment was unsuccessful. However, it was found by numerous experiments that a pre-treatment with a 3 per cent. solution of iodine in potassium iodide was extremely effective where other methods failed. The time of pre-treatment was varied for the different species; the iodine solution was carefully blotted off before the addition of the 72 per cent. sulphuric acid, and careful warming of the slide after the completion of the acid reaction was necessary to bring up the pattern at all clearly. The iodine pre-treatment apparently delays the swelling of the cells and so provides an opportunity for the lignin pattern to form while the cellulose is being slowly dissolved. The final warming makes the pattern more distinct, but if not done carefully spoils the whole effect. Using the iodine pre-treatment and subsequent steps, cross sections of all the dicotyledonous woods listed above were examined.

By the use of the methods described, quite a range of cell wall lignin patterns was obtained. In a number of cases no modification of either treatment was successful, and for such species it was assumed that the cell walls were lightly lignified or completely unlignified. It is very difficult to record degree of lignification and intensity of cell

* For Figs. 1 to 12, see Plates 3 and 4.

wall pattern, but an attempt has been made to place the results for the various species into one of the following four classes (see Table 1):—

TABLE 1.—SHOWING GROUPING OF SPECIES ACCORDING TO CLASSIFICATION DRAWN UP.

Class A.	Class B.	Class C.	Class D.
aucaria cunninghamii (compression wood)	*Araucaria cunninghamii* (normal wood)	*Acradenia frankliniae*	*Acacia dealbata*
nus radiata (normal and compression wood)	*Podocarpus amara*	*Ailanthus imberbiflora*	,, *penninervis*
eudotsuga taxifolia (normal and compression wood)	*Ackama muelleri*	*Aphananthe philippinensis*	*Aesculus hippocastanum*
searia battiscombei	*Cardwellia sublimis*	*Castanea tunggurut*	*Betula papyrifera*
ryphora sassafras	*Casearia battiscombei*	*Cinnamomum oliveri*	*Castanea sativa*
malium foetidum	*Doryphora sassafras*	*Elaeocarpus grandis*	,, *tunggurut*
deroxylon australe	*Eucalyptus diversicolor*	*Embothrium wickhami*	*Euroschinus falcatus*
trameristа glabra	,, *marginata*	*Eucalyptus astringens*	*Fraxinus excelsior*
randra corniculata	,, *obliqua*	*Fraxinus excelsior*	*Hicoria ovata*
llaresia moorei	,, *regnans*	*Litsea reticulata*	*Pseudomorus brunoniana*
	Geissois benthami	*Schizomeria ovata*	*Salix nigra*
	Gmelina leichhardtii		
	Lophopetalum sp.		
	Melia dubia		

A—Cell wall lignin pattern very distinct, easy to obtain, and generally made distinct by heating treatment alone.

B—Cell wall lignin pattern fairly distinct but not conspicuous, fairly easy to obtain but only after iodine pre-treatment.

C—Cell wall lignin pattern not distinct, sometimes revealed after careful pre-treatment with iodine.

D—No cell wall lignin pattern, or, in some cases, complete solution of cell wall.

The described methods for revealing the cell wall lignin pattern were also applied to longitudinal sections from the various species. Experiments showed that tangential sections of 15μ thickness cut into small squares of approximately 2 to 3 mm. were the most suitable for obtaining satisfactory results. With *Araucaria cunninghamii* (normal and compression wood), *Tsuga heterophylla* (normal and compression wood), *Tetramerista glabra* (Fig. 2), *Homalium foetidum*, and *Sideroxylon australe*, the pattern was intensified easily by warming slightly after the acid treatment. With other species examined, namely, *Ackama muelleri, Eucalyptus regnans, Eucalpytus obilqua, Acacia dealbata, Litsea reticulata, Cardwellia sublimis,* the iodine pre-treatment was used. Neither the *Acacia dealbata* nor the *Litsea reticulata* gave any definite indication of pattern even with this treatment. The patterns obtained from normal and compression wood of *Araucaria cunninghamii* are illustrated in Figs. 7, 8, 9 and 10.

4. Results of Staining Reaction on the Cell Wall of the Species Investigated.

To reveal the "so-called" lignified secondary walls of tropical timbers, Clarke (4) used safranin (1 per cent. aqueous) followed by fast green F.C.F. (1 per cent. alcoholic) and found that the cell wall of the more heavily "lignified" tropical species stained red and that of the species from temperate zones stained green. Botanical textbooks (3, 12) recommend safranin followed by light green as an effective stain for distinguishing between cellulose and lignified tissues, the

latter staining red and the former green. This double staining procedure was adopted in the experiments reported in this paper, with the object of determining the relation if any between visible amounts of cell wall lignin and degree of so-called lignification according to staining procedure. For this purpose, cross sections 15 to 18μ in thickness of each species under investigation were warmed for 2 minutes on a microscope slide with 1 per cent. aqueous safranin. The sections were washed with 50 per cent. alcohol until the safranin stain was no longer removed in any quantity. One per cent. alcoholic light green was then added for 1½ minutes, rinsed off with 90 per cent. alcohol, and the sections finally differentiated in 98 per cent. alcohol before mounting in the usual way. Results of microscopic examination of the stained sections are given in Table 2. For ease of reference, the type of cell wall pattern obtained has been indicated in the same table by reference to the class into which each species was segregated, using the notations A, B, C, or D, as the case might be. More detailed experiments on the use of this stain for determining cell wall composition have been carried out and will be reported later.

Table 2.—Colour of Secondary Wall of Dicotyledonous Woods after Staining with Safranin and Light Green under Conditions Enumerated.

Cell Wall Red.		Cell Wall Partly Red, Partly Green.		Cell Wall Green.	
Aphananthe philippinensis (normal fibres)	C	*Acradenia frankliniae*	C	*Acacia dealbata*	D
		Ailanthus imberbiflora	C	,, *penninervis**	D
Cardwellia sublimis	B	*Doryphora sassafras*	B	*Aesculus hippocastanum*	D
Casearia battiscombei (normal fibres)	B	*Eucalyptus regnans* (early wood)	B	*Aphananthe philippinensis* (gelatinous fibres)	C
Castanea tunggurut	C	*Gmelina leichhardtii*	B	*Betula papryrifera*	D
Eucalyptus diversicolor	B	*Lophopetalum*	B	*Casearia battiscombei* (gelatinous fibres)	B
,, *astringens*	C				
,, *marginata*	B			*Castanea sativa*	D
,, *obliqua*	B			*Cinnamomum oliveri* (red in some cells of late wood)	C
,, *regnans* (late wood fibres)	B				
Fraxinus excelsior (late wood fibres some samples)	C			*Elaeocarpus grandis*	C
				Embothrium wickhami	C
				*Euroschinus falcatus**	D
Homalium foetidum	A			*Fraxinus excelsior*	D
Schizomeria ovata	C			*Hicoria ovata* (last rows latewood red)	D
Sideroxylon australe	A				
Tetramerista glabra	A			*Melia dubia** (late wood cells red)	B
Urandra corniculata	A				
Villaresia moorei	A			*Pseudomorus brunoniana**	D
				Salix nigra	D

Notes.—(1) Those species marked with an asterisk contain numerous gelatinous fibres, the walls of which always stain green with this double staining procedure.

(2) Of the species showing a red cell wall in this staining procedure, five fell into Class A, six into Class B, five into Class C, and none into Class D, of the classes listed in Table 1.

(3) Of the species with a green cell wall after this staining procedure, two fell into Class B, four into Class C, and ten into Class D of the classes listed in Table 1.

5. Discussion.

At the outset it is as well to stress the point that the amount of cell wall lignin is comparatively small in relation to the lignin of the intercellular zone. While the former appears very abundant in photomicrographs, it is after all only a faint pattern that has been intensified firstly by preliminary treatment and, secondly, by the photographic process. Also, the possibility that all the carbohydrate material may not be completely dissolved in the acid treatment must be borne in mind. However, by far the greatest portion of the residue is lignin, plus, in some instances, such as jarrah (*E. marginata*), insoluble extraneous materials from the cell cavities. The main point is that with many species a definite cell wall pattern can be revealed after treatment with 72 per cent. sulphuric acid, and this pattern can be no accident because it is so pronounced and because under the best conditions it is found in every fibre wall. That this pattern is not connected with the hemicelluloses of the wood was proved by boiling sections of *Tetramerista glabra* with 3 per cent. sulphuric acid for 4 hours, which treatment supposedly removes all such materials (5). The cell wall pattern was found to be identical both before and after the treatment. This was also the case when sections of various species (*Tetramerista glabra, Casearia battiscombei, Eucalyptus regnans*) were boiled with 0.08 per cent. NaOH for 20 minutes.

The methods of technique developed to show the pattern of the cell wall were found to be very simple to use and quite effective with a large number of the species examined. Where repeated trials failed to give any cell wall pattern, it has been considered that the nature of the secondary wall is such that very little lignin is present. In a number of the species in which it was not possible to demonstrate the cell wall lignin, numerous gelatinous fibres, of the type with a single gelatinous layer, were observed. It has long been recognized that the secondary wall of such fibres consists mainly of cellulose; in the present experiments it was not possible to find any lignin in the walls.

From consideration of the results obtained with the species selected, it will be seen that, in general, the thicker the cell wall the more likely the chance of demonstrating cell wall lignin pattern. Bailey and Kerr (1) have reported difficulty in obtaining lignin patterns with lightly lignified woods of dicotyledons of the temperate regions. These timbers very largely fall into the thin-walled class. There seemed to be some degree of correlation between thickness of cell wall, cell wall lignin pattern, and the staining reactions of the secondary wall using safranin followed by light green. Of the sixteen species with secondary wall staining red in the present investigations, nine have thick walled fibres and six have fibres whose thickness of wall is approximately equal to the diameter of the lumen; twelve of these species gave a lignin pattern without much difficulty. On the other hand, of the sixteen species with green cell wall (the latewood fibres of some showed red cell wall) thirteen had thin fibre walls or gelatinous fibres; cell wall lignin patterns could not be demonstrated in ten cases and only with difficulty in four cases. Thus, from the evidence of the experiments recorded in this report, it would seem that, first of all, ease of demonstrating the presence of cell wall lignin is somehow related to thickness of cell wall, and, secondly, that the staining reaction used gives at least some very good indication of the presence of lignin in the secondary wall.

The action of the sulphuric acid causes tremendous swelling of the cell wall, and this, in nearly all cases, disrupts the lignin framework of the intercellular zone. Where no cell wall pattern could be obtained, e.g., where the secondary wall was a single gelatinous layer, it was usually impossible to retain any outline of the cell because the swelling was so great. This is perhaps understandable on the theory that the secondary wall in these species contains relatively small amounts of lignin. Such a theory is substantiated (i) by the green stained secondary wall indicating cellulose and no lignin (see above), which condition is found in every one of the species falling into Class D, and (ii) by the complete failure to obtain any cell wall lignin pattern. On the other hand, with the thicker-walled species, while the swelling of individual cells was very marked, such cells retained their identity and the cell wall lignin pattern could be revealed. In these cases it is possibly the greater amount of cell wall lignin present that tends to restrict the swelling of the cellulose. With the coniferous woods the cell wall pattern is easily and quickly demonstrated in the thicker-walled latewood tracheids, but, although it is evident that lignin is present, it is practically impossible to obtain a coherent pattern with the thin walled early wood tracheids because of the tremendous swelling. This swelling causes great distortion of the cell wall but does not always disrupt the lignin framework of the intercellular zone. The very thick-walled compression wood tracheids and fairly thick-walled tracheids of the late wood do tend to swell outwards and burst this framework. On the whole, however, the swelling of the secondary wall of the tracheids of coniferous woods is much less in comparison with that of the secondary wall of the fibres of dicotyledonous woods, and this may possibly be attributed to the relatively larger amount of cell wall lignin in coniferous woods, (actual lignin content of these woods is higher than that of dicotyledonous woods in general (16), and the lignin content of compression wood is still higher (6)).

Bailey and Kerr have recorded that the structural patterns of the secondary walls of tracheids and fibres are not constant for any particular species varying in different parts of the same stem and even at times of the same cell. They concluded that there are:—(i) layers which have a prevailing concentric structure throughout, (ii) layers which have a dominantly radial pattern, and (iii) layers which exhibit various complex, intermediate, or radio-concentric structures. From the results obtained in the present survey, it is considered that the radio-concentric pattern is the predominant one found in normal tracheids or fibres (Figs. 11 and 12). Fundamentally, there appeared to be a fine radial arrangement which is intensified at more or less regular intervals giving some concentric appearance which is more marked at lower magnifications (up to 400x). At magnifications of 1,000, this concentric arrangement seems to give way to a fine radial arrangement. Similar differences were noted when the degree of swelling has varied in the one section. Thus it may be that variations in the radio-concentric pattern are due to some extent to the variations in the degree of swelling undergone by the cells.

Exceptions to this predominantly radio-concentric pattern were found, (i) with compression wood tracheids, (ii) with gelatinous fibres of *Casearia battiscombei* (Fig. 4), (iii) with *Homalium foetidum* (compare Bailey and Kerr), and (iv) with some fibres of *Sideroxylon australe* (Fig. 5). The compression wood and tracheids of *Araucaria*

cunninghamii (Fig. 9), *Pinus radiata* (Fig. 6) and *Tsuga heterophylla* all gave the same distinct coarse radial pattern which was very distinct from the radio-concentric pattern obtained with the normal wood tracheids. Where compression wood was not so marked, the radial pattern was finer and not so distinct. Bailey and Kerr have referred to this radial pattern in coniferous tracheids developed under the influence of geotropic stimuli, but their photomicrographs do not reveal such a distinct coarse radial pattern as shown in Figs. 5 and 9. Why, in response to geotropic stimuli, the cell wall of compression wood tracheids is developed so differently from that of normal wood tracheids is not definitely understood. There is no indication of any growth rings in the wall pattern (a suggestion to explain the concentric pattern) and it may be that the whole secondary wall of these tracheids is laid down quickly in one burst of growth under the conditions of geotropism which cause the development of compression wood.

Bailey and Kerr have suggested that, in the case of the dicotyledonous woods, the conspicuous radial and radio-concentric patterns are derived from gelatinous fibres. Such fibres occur sporadically in many genera belonging to different families and tend to be concentrated on one side of the stem at any one period of growth (13), or in parts of stems and branches that are developing under the influence of tropistic stimuli (10). They have been shown to be associated with the formation of tension wood. Although a number of species showing gelatinous fibres were included in the present investigation, no definite cell wall lignin pattern was obtained with any of those showing the single gelatinous layer. In the case of *Casearia battiscombei*, however, the gelatinous fibres gave an abnormal pattern (Fig. 4) similar to that obtained with *Homalium foetidum*. Both these species belong to the Flacourtiaceae, and Bailey and Kerr have pointed out that various members of this family have fibres with actual discontinuities in the cellulose matrix produced by narrow isotropic films of a non-cellulose nature. Such fibres may be of the gelatinous type but with two to several distinct layers.

Of the other species investigated only *Sideroxylon australe* (Fig. 5) showed the distinct radial patterns similar to those recorded by Bailey and Kerr for *Siparuna bifida*. There was no indication from the staining experiments that gelatinous fibres were to be found in the particular piece of the timber investigated. However, too little is known of the abnormal fibres developed in dicotyledonous woods as a result of geotropic stimuli, and further work on tension wood and tension wood fibres is necessary.

Examination of the cell wall lignin pattern in tangential sections showed a fine longitudinal network made up of layers at a very small angle to the long axis of the fibre. This pattern was obtained with the normal tracheids of the coniferous woods and normal fibres of the dicotyledonous woods. On the other hand, in compression wood tracheids, the very fine layering is at an angle of 60° to 70° to the long axis (see Figs. 8 and 10). The various dicotyledonous woods examined did not show any variation in the fine longitudinal network pattern even in those species where anomalous fibres were suspected, e.g., *Sideroxylon australe*. The longitudinal section of *Homalium foetidum* showed the distinct layering of the cell wall, but in each layer a fine network similar to that observed with other dicotyledonous woods could be detected.

The work reported in this paper is of importance as a starting point for a number of separate investigations. Firstly, it was necessary to develop a suitable routine procedure for revealing cell wall lignin, so that the influence of those chemical treatments used in the isolation of holocellulose and cellulose on such lignin could be followed. Secondly, it should be now possible to determine the full extent of the value of staining reaction—safranin followed by light green—in showing up the degree of lignification of the secondary wall. Thirdly, further work may indicate the correlation between amount of cell wall lignin and impact strength of the wood. And, fourthly, the nature and occurrence of the fibres or types of fibres in dicotyledonous woods giving a distinctive radial cell wall pattern need to be investigated thoroughly.

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PLATE 1.

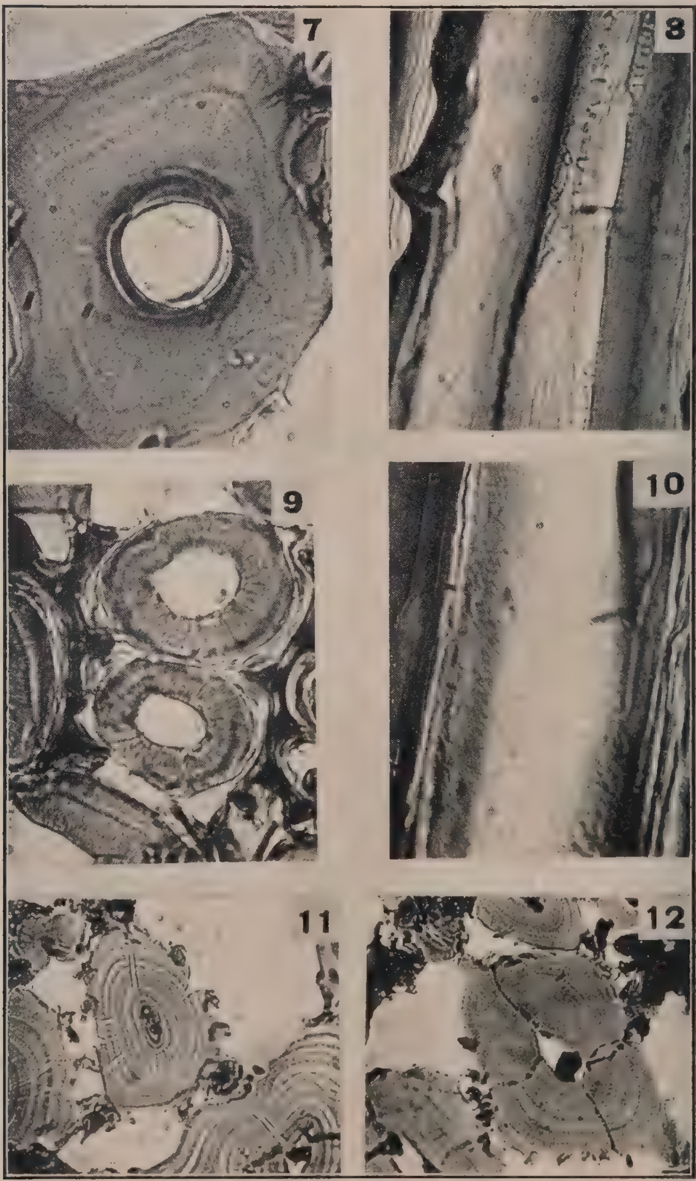
The Control of Cumbungi in Irrigation Channels (See page 1).

FIG. 1.—Note the dead stems of Cumbungi after the cutting treatment.

FIG. 2.—Lateral supply channel completely blocked by Cumbungi.

PLATE 4.

Contributions to the Study of the Cell Wall (See page 44).



7 and 8 *Araucaria cunninghamii.*—Cross and radial sections; lignin pattern from normal wood tracheids after 72 per cent. H_2SO_4 and gentle warming. × 550.

9 and 10. Same as 7 and 8 but compression wood tracheids. × 550.

11. *Eucalyptus diversicolor.*—Cross section showing the lignin pattern after treatment with iodine-potassium iodide followed by 72 per cent. H_2SO_4 and warmed. × 550.

12. *Ackama muelleri.*—Cross section after similar treatment to that in 11.

NOTES.

New Laboratory for Work on Australian Fruit Juices.

The erection of a small laboratory building to house special fruit juice investigations is now just about complete; the building is located alongside the main laboratory of the Council's Section of Food Preservation and Transport at Homebush. The total cost for erection and equipment of the new laboratory will amount to about £2,800, of which £2,000 will come from the Council's vote, and £800 from the Revenue fund derived from the sale of fruit at the Griffith Research Station, the New South Wales Water Conservation and Irrigation Commission which has an interest in that Revenue having agreed to the allocation.

Judging from the various approaches that have been made to the Council in the past, there is no doubt that there is a persistent demand on the part of the Australian fruit growing industry for assistance in the utilization of surplus and culled fruit of all varieties. With the outbreak of war and the consequent difficulty of exporting anything like the usual proportion of the Australian fruit crop, this demand has been accentuated.

Much work on the general problem has been carried out in other countries, e.g., by Professor Cruess and his team at Berkeley, California, and as a result a considerable amount of information is available regarding the various avenues of disposal in the form of juice, dried fruit, crystallized fruit, &c., but on the other hand this information is in many cases not directly applicable to the particular fruit grown in Australia.

Of late, there has been much activity in other countries in the utilization of fruit in the form of fresh fruit juices. In August, 1937, the Second International Congress for the Utilization of Unfermented Fruit Juices was held in Berlin. On that occasion, an officer of the Council (Mr. N. E. Holmes) who attended the Conference reported that the production of the juices in question had reached large proportions in Continental centres, and that the general tone of the discussions indicated that a considerable increase in production might reasonably be expected.

In July, 1938, the Council was furnished by the Department of Commerce with a copy of a detailed report on fruit juices by the Department's Fruit Officer in London (Dr. T. H. Harrison). This report, too, drew attention to the large amount of work being done on fresh fruit production in European countries.

From information received by the Council, some 200 million gallons of the fresh fruit juice were prepared by the United States of America in the year 1938 from about 1,000,000 tons of fruit. In America, pineapple, tomato, and citrus juices are the most important from the commercial point of view, but an increasing consumption of apple and cherry juices is likely in the near future. In Europe, apple juice is by far the most important fresh juice at the present time.

The whole question of fruit juice research was raised by the Council at a meeting of the Standing Committee on Agriculture held in Perth in September, 1938. The Committee was in accord with the proposals put forward to the effect that some work should be commenced by the Section of Food Preservation and Transport. The Australian Agricultural Council also supported the proposal, and recommended that the necessary funds should be provided.

Following that recommendation, the Commonwealth Government subsequently authorized the Council to proceed with its plans for the establishment of the special fruit juice laboratory at Homebush.

Prior to the erection of this new laboratory, a small commencement had already been made by the Section on orange and pineapple juices. Attention has also been given to the selection of suitable lacquers, and methods of applying them to the cans to prevent metallic contamination of canned juices. In the new laboratory, attention will first be given to apple, citrus, pineapple, grape, and prune juices, and later it is hoped to work on tomato, passion fruit, berry, and some vegetable juices.

The production of fruit juices in a new environment is not, as a rule, simply a question of applying the methods of extraction, sterilization, &c., used elsewhere: much preliminary investigation is generally needed if juices of a uniformly high quality are to be produced. A rather elaborate processing technique is necessary with most fruits to produce a stable, sterile juice, and some of the treatments, particularly sterilization, may have a marked effect on the flavour of the juice. Since different varieties of the same class of fruit differ materially in their response to treatment, it is necessary to study the effects of variations in treatment with each variety in order to define the most satisfactory processing technique. The stage of maturity at which the fruit is picked also affects the response to treatment. Moreover there are difficulties to be overcome before juice of the right flavour to suit the public's taste can be produced. From this point of view the natural sugar-acid ratio is most important. This ratio varies both with variety and maturity, and blending of juices is practised to obtain a product with the desired sugar-acid ratio and also a suitable balance in the other constituents affecting flavour. Thus for the production of apple juice in Australia much remains to be learnt regarding details of blending, clarification, sterilization, storage, and carbonation, and there are similar problems with regard to other juices.

Juices are already being produced by various commercial organizations in Australia, but most of these are still working on a relatively small scale. The primary object of the work in the new laboratory will be to obtain information necessary to ensure development of the industry on sound technical lines.

Due attention will be given in the research programme to a study of costs of production, but sufficient is known already to support the view that the production of fresh fruit juices cannot be carried out particularly cheaply. Accordingly, the market will not be unlimited and fruit juices will not give a complete answer to the utilization of surplus and cull fruit. They may, however, reduce that problem to some extent.

Research by Manufacturers in the United States of America.

The 6th edition of a publication by the U.S. National Research Council recently issued as its Bulletin 102, under the title "Industrial Research Laboratories of the United States," gives a remarkable bird's eye view of the extent to which American industrialists are engaging in scientific research.

The Bulletin names no less than 1,769 companies having laboratories devoted entirely to research; it does not list laboratories which are merely concerned with the routine testing of raw materials and products, but it includes all those which definitely devote some time to research looking towards the improvement and development of products.

The questionnaires on which the Bulletin is based requested information concerning the location of the laboratory, the size of the research staff, the fields of science or of engineering represented, research activities, serial scientific publications issued, and co-operative research supported. All those details are given in the publication.

The Bulletin is now in its 6th edition. The previous edition, issued in 1933, contained a list of 1,575 laboratories.

The laboratories connected with Federal, State, and Municipal Governments have not been included, except the National Bureau of Standards. The Bulletin states that "this Bureau co-operates closely with industry and it seems essential to include a statement concerning its work which would be readily available to companies using this publication. A laboratory in an educational institution is included only when it is directly supported by industry rather than by the institution."

A perusal of the publication gives the reader an excellent idea of how even the small manufacturing concerns of the United States devote a considerable proportion of their energies to investigational work. Thus a typical entry for a small concern is as follows:—

Research Staff—1 chemist, 1 physicist, 1 engineer—total laboratory personnel 5. Research activities: the physical and chemical investigation of leather with particular reference to leather belting, packing leather, and leather strapping.

Another typical entry on the small side is a research staff of 2 chemists, 1 engineer, and 1 other scientific employee. Research activities: improvement in zeolites for water finishing purposes; the improvement of mechanical devices for water softening and filter purposes; iron and manganese removal from water; pH control of water; water conditioning for municipal supply; softening problems for industrial and domestic water supply.

Among the larger organizations, the Dow Chemical Company has three divisions, namely, chemicals, dyes and organic heavy chemicals, and pharmaceutical and allied products with which eight research laboratories are closely interlocked both in research and in technical developments. Serving these are some 500 chemists, physicists, and engineers "capable of dividing their attention as the demand requires."

The E. I. du Pont de Nemours and Co. Inc. has laboratories in different departments, e.g., ammonia department, with a research staff of one director, two assistant chemical directors, and 82 chemists, chemical engineers, and miscellaneous technical employees—also 32 chemists and chemical engineers assigned to the improvement of plant

processes. The research includes development of catalysts for ammonia synthesis and other gas reactions carried out under high pressure, the development of hydrogen production, &c. The chemical department has a research staff of 1 director, 1 assistant director, 3 supervisors, 130 graduate chemists, physicists, and engineers, 79 other salaried employees, and 236 pay roll employees. The research activities include industrial chemical products such as coating compositions, resins, and organic chemical compounds; also a considerable amount of pure science or fundamental research. The explosives department has a total research staff of a director and 60 graduate chemists and engineers. The fabrics and finishing department has research work located in five main centres with laboratory personnel numbering 342. The investigational work includes fundamental research on new resins, and developmental work on paints, enamels, varnishes, and synthetic resins. The Grasselli chemical department has a total personnel of 135. In addition, the company has similar large research staffs connected with its Krebs pigments department, its organic chemicals department, its plastics department, its R. and H. chemicals department, its rayon department, and one or two others.

Toxaemic Jaundice in Sheep—Further Investigations.

Toxaemic jaundice, a disease responsible for a considerable annual loss of sheep in Australia during recent years, has occupied the attention of several investigators for some time past, and recently more intensive co-operative researches have been undertaken. Doubt regarding the cause of the condition has resulted in a number of theories being subjected to exhaustive laboratory investigations and field observations, and no support has been found for the theory of causation by a toxic plant or plants, while bacteriological investigations have failed to attach the responsibility to bacterial organisms.

The disease is limited to fairly well-defined districts of New South Wales and Victoria, but in the past has occurred most commonly in the Riverina. The losses on affected properties in this district are reported to have reached in one case as high as 55 per cent. over a period of nine months, while in another instance a loss of 39 per cent. of a flock of 2,300 breeding ewes was recorded over a period of a year. The losses are practically confined to the British breeds and their crosses, the disease in Merinos exposed to equal risk of infection being merely an interesting curiosity. Age apparently has a bearing upon susceptibility, cases being extremely rare in lambs or one year old sheep, though after this stage susceptibility increases with time.

The occurrence of the disease has not been definitely associated with any particular set of seasonal conditions. Heavy losses in sheep have occurred under semi-drought conditions and on flush pastures in every month of the year and in every season of the year, although the heaviest losses have occurred in the spring and autumn.

The symptoms shown by affected animals are those of general malaise with a staggering gait, pallid or yellow mucosae, skin pale and distinctly yellow in colour, and dark reddish-brown urine. It may occur in the hyper-acute form, in which the sheep are visibly ill for a few hours only, or in the sub-acute form, in which case the animals manifest symptoms for two, three, or even as long as four days. The percentage of recoveries is small.

Post-mortem examination immediately after death shows the liver to be yellow and very friable, kidneys black and enlarged, and nearly all body tissue to be yellow, sometimes with a greyish tinge.

Though the earlier researches into this disease led to rather inconclusive results, data obtained from more recent work suggest that the disease is characterized by an abnormally high copper storage in the liver, and a sudden rise of copper in the blood which apparently leads to destruction of red blood cells and consequently kidney damage.

In the year 1938, a conference representative of the Council, the New South Wales and Victorian Departments of Agriculture, the Veterinary Research Institute of the University of Melbourne, and the Australian Wool Board was held to formulate plans for a co-operative investigation into the cause and prevention of the disease. Later, plans were prepared for investigations to be conducted in the Riverina on an area of approximately 400 acres made available under lease from the New South Wales Closer Settlement Board. The estimated cost of the work for the first year is £1,100, which is being shared equally by the Australian Wool Board and the Australian Meat Board. Some 300 experimental sheep have now been obtained and placed on the area, and an active commencement with the study of preventive methods has been made. The investigations are under the direction of a committee consisting of Mr. W. L. Hindmarsh (Director of Veterinary Research, New South Wales Department of Agriculture), Dr. H. E. Albiston (Director of the Veterinary Research Institute of the University of Melbourne), and Dr. L. B. Bull (Chief of the Council's Division of Animal Health and Nutrition). The field operations will mainly be the concern of an officer of the New South Wales Department of Agriculture (Mr. J. C. Keast). The laboratory work will be shared by the Department and the Council's Division of Animal Health and Nutrition.

Review.

"Plant Hormones and their Practical Importance in Horticulture," by H. L. Pearse.

(Technical Communication 12 of the Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent, England, 1939, p. 88, bibl. 248, 3s. 6d.)

During the past decade or so, great advances have been made in the studies of the growth of plants, and particularly is this so with reference to the use of growth-promoting substances. Dr. Pearse, of the Imperial College, has made an extremely useful and interesting contribution in

this field by preparing for the Imperial Bureau of Horticulture and Plantation Crops a Technical Communication (No. 12) which includes a review of the literature dealing with the application of hormones to horticulture, a tabulation of nearly 1,000 instances of the reactions of plants to these substances, and a comprehensive bibliography on the subject.

Most of the communication deals with the promotion of root growth, and an important section deals with practical methods for the propagator.

Disbandment of the Commonwealth Prickly Pear Board.

In 1919, the Governments of the Commonwealth, New South Wales, and Queensland agreed to co-operate for a period of five years to carry out an investigation into the possibilities of biological control of the prickly pear pest, and the Commonwealth Prickly Pear Board was established on the 1st June, 1920. Subsequently, the agreement was renewed from time to time for periods of two and three years and terminated at the end of May, 1939. The cost of the investigations has been borne generally in the proportion of 50 per cent. by the Commonwealth and 25 per cent. by each of the two States. Valuable assistance has also been rendered by the Queensland Prickly-pear Land Commission. Remarkable destructive results, particularly with respect to the main pest pear, *Opuntia inermis*, followed the introduction from South America in 1925 of *Cactoblastis cactorum*. These results have been reinforced by damage caused by other introduced insects, notably species of cochineal (*Dactylopus*) and plant-sucking bugs of the genus *Chelinidea*.

It has been fairly generally felt for some time past that while there undoubtedly remain aspects of the prickly pear problem that require scientific investigation, the necessary information on which the control of the pear might be based has now been obtained, and, in consequence, the Commonwealth Prickly Pear Board might now cease to function, leaving the carrying out of the actual measures of control to the State authorities concerned. Such a feeling is in line with the functions of the Board which have always been of a research rather than administrational nature.

The Board held its last meeting at the end of October last and then outlined various recommendations regarding the disbandment and the carrying on of some of its former activities. These recommendations which are given below have now been approved by the various bodies concerned:—

(*a*) Staff. The whole of the staff of the Board, except two officers who have resigned, will be taken over either by the Queensland or New South Wales authorities or by the Council.

(*b*) Future work.—The Council will continue overseas work on Noogoora burr. The States of New South Wales and Queensland will both continue the prickly pear work in their respective States and will collaborate with each other and with the Council.

(*c*) Queensland Weeds Committee.—Mr. A. P. Dodd is one of the officers taken over by the Queensland authorities; he has been appointed to represent the Queensland Lands Department on the Council's Weeds Committee.

(*d*) Disposal of assets.—The Council will take over the Board's assets overseas. The States of Queensland and New South Wales will take over the assets in their respective States.

(*e*) Publication of results.—Arrangements are being made for the publication of a Bulletin.

The scientific work of the Board was under the control of Professor T. Harvey Johnston until February, 1923; of Mr. J. C. Hamlin from February, 1923, to May, 1924; of Mr. W. B. Alexander from May, 1924, to August, 1925; and of Mr. Alan P. Dodd from October, 1925, until the termination of the Board's existence.

Work on Australian Timbers for Aircraft and other Purposes.

Arrangements have recently been made for an intensification of the work of the Division of Forest Products in so far as strength tests of certain Australian timbers are concerned. The timbers in question—to the number of 8 or 9—are considered to be possible substitutes for timbers now imported for use in small sections, e.g., in aeroplanes, furniture, and some plywoods. Despite a popular belief to the contrary, metal has not entirely replaced wood for aircraft construction, nor is it likely to do so.

With the present difficulties attendant on importation into Australia, the need for substitutes or alternative materials has become urgent in many cases, and it was for this reason that the intensive work in question was decided on. The Division has been granted another £2,500 for the programme and is now working its testing machines with two shifts of operatives daily.

Imported birch is rather widely used for plywood in aircraft construction in Australia. From indications which have already been obtained by the Division it seems that northern silver ash (*Flindersia pubescens*), which is common in Queensland, may easily prove to be a satisfactory substitute.

For work on these comparatively small sections, the Division is carrying out intensive tests, some of which, e.g., the measurement of torsional strength and of the modulus of elasticity across the grain, are not necessary in the more general programme. Further, some 30 trees per species are being tested so that figures more representative of the species as a whole may be obtained.

A valuable feature of such detailed work is that it will facilitate the drafting of specifications on the part of those intending to use these Australian woods. It will also enable a better selection to be made of veneers for particular purposes.

Investigations on the Blowfly Problem—Recent Developments.

The leader of the Council's team of blowfly investigators (Dr. I. M. Mackerras) has recently enlisted and will shortly leave Australia as a medical officer.

At its December meetings, the Executive Committee of the Council discussed the consequent re-arrangement of the investigations with the Interdivisional Committee on Veterinary Entomology (consisting of representatives of the Divisions of Economic Entomology and of Animal Health and Nutrition).

As a result, it is proposed that the Officer-in-Charge of the McMaster Laboratory (Mr. D. A. Gill) will act as liaison officer to keep in touch with every aspect of the Council's blowfly work now in progress at "Gilruth Plains" near Cunnamulla, Queensland, and at Canberra.

Recent Publications of the Council.

Since the last issue of this *Journal*, the following publications of the Council have been issued:—

Bulletin No. 130.—"Chemical Investigations on the Fleece of Sheep," by Martin R. Freney, B.Sc.

The work discussed in this publication forms part of the programme of the Division of Animal Health and Nutrition; it was put in hand in order to learn more about the fleece of sheep and the way in which the nature of the fleece is related to the environment of the animal.

Taking the Australian wool clip as a whole, it is probable that only from 50 to 55 per cent. of its weight represents actual wool fibres. Apart from dust and vegetable debris, the total annual clip contains approximately 80,000 tons of wool wax and 30,000 tons of suint. The report deals in the main with the investigations that have been carried out to determine what may be regarded as the normal variations in the fleece constituents and to discover reliable and practicable methods of sampling. The results will serve as a basis for a study of such matters as "fleece rot" or the susceptibility of the sheep to attack by blowflies. A review of the present knowledge of the chemistry of each of the fleece constituents is included. Part of the work discussed was facilitated by a capital grant from the Australian Wool Board.

Pamphlet No. 94.—" Some Effects of Alkaline Reagents on Wool." 1. Chemical Studies with Special Reference to Felting and Shrinkage, by M. R. Freney, B.Sc., and M. Lipson, B.Sc. 2. Preliminary Notes on the Physical Properties of Alkali-treated Wools, by E. H. Mercer, B.Sc., and M. R. Freney, B.Sc.

The authors of this publication are located in the McMaster Animal Health Laboratory of the Division of Animal Health and Nutrition. The studies discussed in the publication did not result from a direct attack on the problem of felting and shrinking of woollen fabrics, as that problem has no direct concern for workers in the field of animal health; they resulted from certain inquiries being made into the character of the wool fibre. It was found that wool can be modified by treatment with alkali under controlled conditions in the relative absence of water and that the modification thus produced does not weaken the fibre, but imparts to it certain properties which may affect its field of usefulness.

The process evolved may, when properly controlled, be used to produce a wool with reduced tendency to shrink through felting. Since satisfactory treatment can be obtained by immersing the wool for one or two minutes, the process can be applied so as to treat wool tops continuously in machines of the back wash type. Special care is necessary, however, when neutralizing the alkali, as dilute solutions of alkali damage the wool though stronger ones do not. Wool treated in top form can be satisfactorily processed in the subsequent stages of manufacture. Treated wool dyes satisfactorily. Wearing and washing tests made of wool treated in the way described have given results equal to those obtained with garments sold in commerce as being unshrinkable.

The work discussed in the publication was partly financed by contributions generously made available by the Australian Wool Board.

Forthcoming Publications of the Council.

At the present time, the following future publications of the Council are in the press :—

Bulletin No. 131.—" Black End and Anthracnose of the Banana with Special Reference to *Gloeosporium musarum* Cke. and Mass.", by J. H. Simmonds, M.Sc., and R. S. Mitchell, M.Sc.Agr.

Bulletin No. ? .—" The Wood Anatomy of Some Australian Lauraceae with Methods for Their Identification," by H. E. Dadswell, M.Sc., A.A.C.I., and Audrey M. Eckersley, M.Sc.

Bulletin No. ? .—" A Soil Survey of the Mildura Irrigation Settlement, Victoria (First Mildura Irrigation Trust)," by F. Penman, M.Sc., G. D. Hubble, B.Agr.Sc., J. K. Taylor, M.Sc., B.A., and P. D. Hooper.

Pamphlet No. 92.—" The Density of Australian Timbers, Part II., Air-dry and Basic Density Data for 172 Timbers," by W. L. Greenhill, M.E., Dip.Sc., and H. E. Dadswell, M.Sc., A.A.C.I.

Pamphlet No. 93.—" Studies on the Marketing of Fresh Fish in Eastern Australia. Part I.—Field Observations and Quantitative Bacterial Results," by E. J. Ferguson Wood, M.Sc., B.A.

Pamphlet No. 95.—" Australian Apples—A Guide to Picking for Export or Local Storage and to the Best Shipping Periods for Export Varieties," by W. M. Carne, F.L.S.

Pamphlet No. ? .—" Further Investigations on Copper Deficiency in Plants in South Australia," by D. S. Riceman, B.Agr.Sc., C. M. Donald, B.Sc.Agr., and S. T. Evans, B.Sc.

Miscellaneous.—" Handbook of Structural Timber Design," prepared by the Division of Forest Products. This handbook gives the necessary information, formulae, design data, &c., for the design of timber structures; tables showing the load-carrying capacities of timber beams and columns are included.

T. Rider, Government Printer, Melbourne.

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